1-1-1891

The creamery industry

John A. Myers

VOL. II. NO. 1.

Bulletin No. 13

OF THE

WEST VIRGINIA

Agricultural Experiment Station.

MORGANTOWN, W. VA.

THE CREAMERY INDUSTRY.

—BY—

JOHN A. MYERS, Ph. D.

Director.

JANUARY, 1891.

CHARLESTON, W. VA.
Moses W. Donnally, Public Printer.
1891

BOARD OF REGENTS OF THE WEST VIRGINIA UNIVERSITY.

District.	Name of Regent.	P. O. Address.
1.	J. B. SOMMERVILLE,	Wheeling.
2.	CLARENCE L. SMITH,	Fairmont.
3.	PEREGRIN HAYES,	Glenville.
4.	D. D. JOHNSON,	Long Reach.
5.	JOHN G. SCHILLING,	Spencer.
6.	EDWARD A. BENNETT,	Huntington.
7.	WIRT A. FRENCH,	Princeton.
8.	M. J. KESTER,	Union.
9.	J. F. BROWN,	Charleston.
10.	THOS. J. FARNSWORTH,	Buckhannon.
11.	JOSEPH MORELAND,	Morgantown.
12.	JOHN A. ROBINSON,	Patterson's Depot.
13.	DR. W. W. BROWN,	Kabletown.

MEMBERS OF THE STATION COMMITTEE.

JOHN A. ROBINSON, JOHN G. SCHILLING,
JOSEPH MORELAND, THOS. J. FARNSWORTH,
DR. W. W. BROWN.

PRESIDENT OF THE UNIVERSITY. TREASURER.

E. M. TURNER, LL. D., JOHN I. HARVEY.

STATION STAFF

JOHN A. MYERS, PH. D., ... Director.
CHAS. F. MILLSPAUGH, M. D., Botanist and Microscopist.
RUDOLPH J. J. DE ROODE, PH. D., . . Chemist
D. D. JOHNSON, A. M., ... Agriculturist.
A. D. HOPKINS, ... Sp'l Agt. Entomology
SUSIE V. MAYERS, . . Stenographer and Book-keeper.

The conditions under which we are attempting to develop the creamery industry in this State, are different from those existing in the sections of the country, in which the bulk of the published work upon this branch of industry has been done.

Our experience leads us to disagree in several particulars with accepted ideas promulgated by competent authorities upon the best methods of handling milk and cream for the manufacture of butter. We are quite clear that some of the principles promulgated by our friends further north, and generally accepted as true, are not the most applicable in this latitude and farther south. We have not concerned ourselves with the manufacture of cheese, with the concentration and canning of milk, nor with the utilization of any of the by-products. Our skim-milk goes for feed, and our cream is either disposed of as cream, or as butter. The energies of the Station in this investigation have been concentrated upon the problems of handling milk and cream, so as to make the butter business profitable to the farmer.

Elsewhere, much attention has been given to the raising of cream, and to the care with which milk should be handled before going to the churn, and to the vessels, whatever their character may be, for raising the cream and for skiming it.

According to those pursuing what I may term the old plan, the milk must be subjected to the most careful treatment. Where milk must be kept for hours for the cream to rise, the danger of its becoming contaminated is correspondingly increased. I apprehend, that too much stress has not been laid upon the necessity of having all vessels containing the milk scrupulously clean. The air, room, water, and everything near where the milk is kept, should under that system, receive careful attention, and be freed from every contaminating influence.

The effect of temperature upon milk is felt in three directions:

1st In the ratio of skimming, or the extent to which the total butter fat in the milk is secured in the cream.

2nd. In the volume per cent. of the cream. or the relation that the volume of cream bears to the volume of milk.

3rd In the composition, or fat content of the cream.

In regard to the first, the ratio appears to become greater as the temperature is higher. In regard to the second, the per cent. is greater as the temperature is lower, and as regards the third, the per cent. is greater as the time is lon er. Then, the questions of the character of the vessels in which the milk is kept; the agitation that the milk receives; the food of the cattle, the breed of the cattle, and many other conditions enter into the question which it is not necessary for me to discuss at length, as those particularly interested in this form of dairying have given it ample attention.

The cream by this system may be skimmed by what is known as the deep-setting process, or by the shallow setting process. Under the head of deep setting process, there are numerous forms of pat-

ent vessels intended to facilitate the rising of the cream and the removal of the milk and cream from the jars, and to regulate the temperature so as to secure the most favorable conditions for obtaining all of the cream from the milk. Among the deep setting systems, I may mention The Cooley Creamer, The Haney Patent Cream Setter, Common Sense Cream Setter, Crescent Creamery and Refrigerator, Excelsior Cooling Vat, Moseley's Occident Creamery and Stoddard Creamery. The cans are generally about 8 inches in diameter and from 18 to 20 inches in height, usually with a glass window or some device upon the side which carries a scale in inches and fractions to facilitate the determination of the quantity of cream raised. The Cooley system entirely submerges the can in cold water. The Stoddard sets the can deeper in the water than the milk rises upon the inside of the can. Other systems of raising cream by deep setting usually employ either the one or the other of these methods, but produce some modifications in the method of taking the cream from the can.

The shallow setting system is practiced by the use of shallow tin pans or crocks, or occasionally wooden vessels placed in cold water, or cold dry air where the cream is allowed to rise, and is then skimmed off with a ladle or large spoon.

Whatever the system used, it is important that the milk be placed in the can as soon as possible after it is drawn from the cow, and should not be agitated any more than can be avoided during cooling. The temperature should be reduced to as near 42 degrees F. as possible. If the spring water will not cool the milk to at least 48 degrees F., ice should be used. The deep setting system is perhaps the more perfect, and represents the latest improvements in handling milk by this process. It works very satisfactorily whenever ice can be had at nominal cost, or where there is abundance of cold water. In either case, if the temperature be not reduced sufficiently the separation of the cream is liable to be imperfect, and a considerable per cent. of the butter fat in the milk may not be secured. In Ohio county in this State where it was tried upon quite a large scale, it proved unsatisfactory to the farmers. Few if any of them preserving ice, and the springs generally not being cold enough in the summer to sufficiently cool the milk.

Creameries using this system usually collect the cream at stated periods and pay the farmer a contract price for the cream according to its quality. If our farmers could be induced to store ice, it would, no doubt be satisfactory in this section, as it is farther north. But we believe that in this latitude and farther south, it will be better to adopt another method, and rely upon the centrifuge to overcome the climatic difficulties, which it does most fully.

By adopting this system, we do away with the instructions so minutely given in regard to handling the milk. The farmer sees that his milk pails and cans are kept clean and fresh, and gives himself no farther trouble about the milk after it is delivered fresh to the creamery. The creamery-man and his machinery do the rest. If the farmer wishes his skim-milk for domestic uses or for feeding

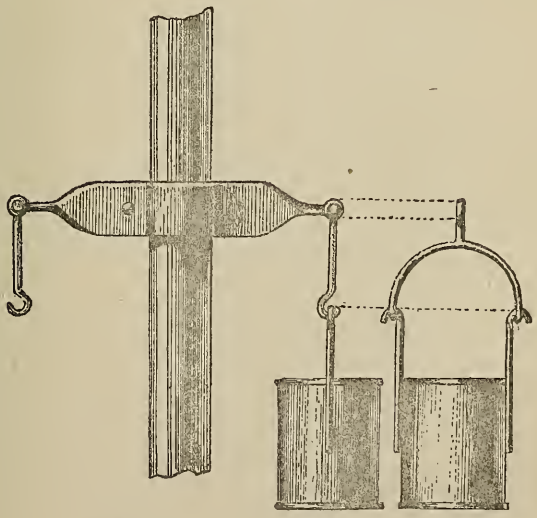
calves or pigs, he can arrange with the creamery for as much as he wishes.

He delivers his milk and is paid for it by the creamery according to the quality and quantity of milk supplied.

The theory of the rising of the fat globules of the cream to the surface is very simple. Cream rises because the fat globules of which it is composed are slightly lighter than the liquid in which they are suspended. This very slight difference in weight is more marked in some cases than in others, probably due to the larger size of the fat globules in some kinds of milk. The rising of the globules is retarded by the serum of the milk which gets stiffer and stiffer as the milk cools, increasing its vicosity, causing the cream to raise slower and slower. The effect being such that if after it is completely cooled the milk be well agitated, much of the cream fails to again rise to the surface, being detained in the body of the liquid by the serum.

The history of the separation of cream from skim-milk is interesting, as showing the manner in which all of our improvements in the arts and sciences are brought about. The centrifuge, as is the case with most great inventions, is not the result of a sudden, brilliant idea; but represents a growth, and is the cumulative effect of a number of efforts to accomplish the separation of cream by mechanical methods. The first effect in this direction appears to have been made by Prof. Fuchs, of Karlsruhe,, in 1859; the method employed by him being simply for testing milk. In 1864, Bayern Antonin Prandtl devised the centrifugal method which consisted of an

Fig. 1.



PRANDTL'S CENTRIFUGE OF 1864.

upright shaft to which arms were attached, upon which buckets containing the milk could be swung. This shaft attached to proper

machinery, and made to revolve at great speed caused the buckets to swing out at right angles, and the centrifugal force in turn caused the cream to rise upon the milk in the buckets, enabling it to be skimmed off by means of a ladel. By running this machine about 400 revolutions per minute, the cream could be made to rise quite perfectly in from 15 to 18 minutes, and by continuing the operation still farther, the cream assumed a thick constitu ence tasting somewhat like butter‡.

No further developments in this line appear to have been made until about 1872, when Prof. Moser, of Vienna, at the Dairy Exposition in that city exhibited a model for the separation of cream by centrifugal force. This machine was somewhat elaborated by Lefeldt, and constructed for handling milk upon a large scale; being exhibited at the Agricultural Exposition of Bremen in 1874. Lefeldt, instead of swinging buckets as Prandtl did, caused metalic cylinders to be attached to the revolving axis. This, however, did not have any practical result so far as its influenae upon the dairy industry was concerned. In 1875, Prandtl brought out an improvement, which provided for the continual skimming of milk by centrifugal action.

This, like the earlier invention, produced no practical results. W. Lefeldt, of Schœningen overcame in 1876 some of the dificulties existing in previous machines, and succeeded in devising a practical machine applicable to the rapid separation of milk and cream. The Lefeldt machine may be considered the original model from which various forms of centrifuges now in use are derived by effecting modifications. It consisted of an iron cylinder driven by steam power at a high speed, into which milk was delivered through an opening in the center at the top. The drum was provided with proper arrangements for enabling it to run evenly upon a small axis or point of support. By causing the cylinder to revolve at a speed of from 800 to 1,000 revolutions per minute, the milk in the cylinder is made to stand upon the outside rim in bands corresponding to the Molkerewesen S. 344 specific gravity of the milk; the cream which is lighter, forming the band next to the center of the cylinder, while the skim-milk which is the heavier, takes position nearest the outs de of the cylinder. This is the principle upon which all of the centrifugal machines act. The more rapidly the machine revolves, the more perfect the separation. After running this machine for some time in order to complete the separation, it was disconnected from the engine, and the cylinder allowed to come to a standstill, when the skim-milk would settle to the bottom of the cylinder, and the cream, as the motion checks, will settle to the center and rise to the top. By syphoning off the skim-milk, the cream is left in the bottom of the drum, from which it could be rinsed out either by water or skim-milk. The machine required at least an hour to separate 100 quarts of milk, and presented the difficulty that it had to be stopped and emptied every time it was full and the separation completed.

‡Dingler Polytechnisches Journal Bd. 174 S. 149.

In 1877 Lefeldt devised an arrangement by which the cream could be separated while the machine was in motion. The cream was skimmed off by introducing a tube in such a position that it would reach the cream as it was separated and rose in the drum. The capacity of this machine was sufficient to lead to its introduction into the first organized creamery at Kiel in 1877, the milk being collected from a number of small farmers at some distance from Kiel and brought to the creamery, which provided the city with a supply of pure milk and butter, and might be considered the first creamery organized for the separation of cream by means of centrifugal force.

It was still necessary to stop the machine to remove the skim-milk, and while a great advance in the application of centrifugal force to the separation of cream had been made, still many defects were apparent. Various improvements were then introduced into the centrifuge, and in 1879 DeLaval brought out what he called a separator, which is now in general use in the creameries of the country, being more or less modified and improved by recent inventions.

Fig. 2 represents the DeLaval separator, which is driven by a band connected with a pulley run by an engine. The speed of these machines has been increased from a few hundred at first to several thousand revolutions per minute. The bowl of the DeLaval separator are tested to 10,000 revolutions per minute, and all of the separators in the market have their bowls or cylinders tested to a very high speed before they are sent from the factory. The centrifugal force at these high rates of revolution becomes so great that it is dangerous to run the machines beyond the speed to which they are tested. Serious damage in several cases has been brought about by persons running them beyond the proper speed and causing the bowl to burst. Those not familiar with running these machines should not attempt it without having some facilities for determining the speed at which they are being driven.

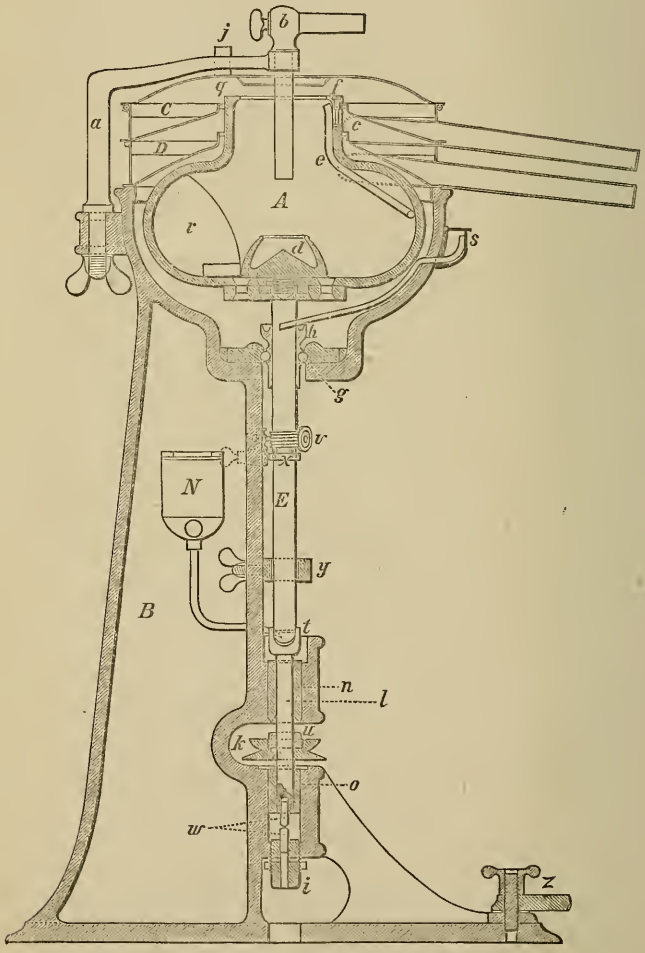
The pressure upon a twelve inch bowl running full of milk at 7,000 revolutions per minute is enormous, amounting to 21,000 pounds to a square inch of cross section. The weight, or tendency of one ounce of metal within the bowl to fly from the center is 562 pounds or over one-fourth of a ton. The constant tendency to tear a wing weighing two ounces from the soldering would consequently be over one-half ton. By a law of mechanics, the centrifugal force increases as the square of the speed. Thus, at 10,000 revolutions, the pressure would be fully double that at 7,000.

At 100,000 per minute, if the distance traveled by the bowl could be drawn out in a straight line, it would be more than six miles a minute. The best cast iron free from flaws would burst at a speed of about 6,000 revolutions per minute. Malleable iron at a little higher speed ; but the cast steel of which the bowls in the De Laval separator are made have the tested tensile strength of 42,000 pounds or twenty-one tons per square inch: It is not surprising, therefore, that great damage is done when the creamery man is so foolish as

to run the separator at a speed of over 10,000 revolutions per minute. We have run our separator up to a speed of about 9,000 revolutions per minute to test it ; but in ordinary operations it is run at 6,000 to 7,000 per minute.

There are in this country at present two prominent machines which we will explain in this connection, as the majority of the farmers in this State are unfamiliar with the principles upon which they act. The cut represents a section of the De Laval Separator, and we are

Fig. 2.



SECTION OF THE DE LAVAL SEPARATOR.

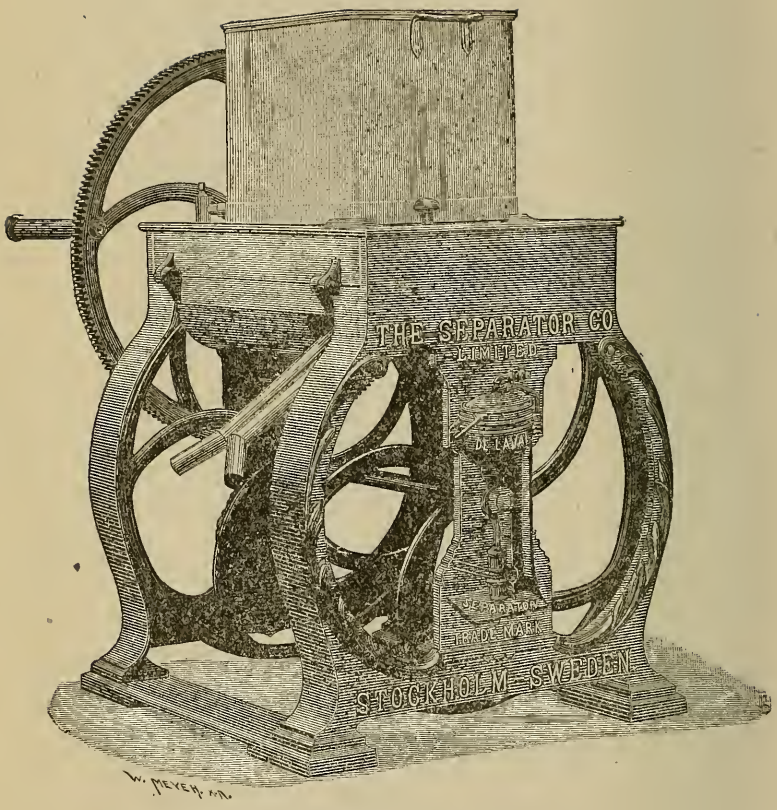
looking at it as a person would look at the flat side of an apple cut in halves. "A" is the bowl of the separator supported by a spindle

"E" which is set in motion by a pulley "K" in which a belt, driven by steam or horse power, runs. The bowl is supported upon two narrow steel points at "w" which reduces the friction to a minimum. "B" is the iron support for the machine. "S" and "N" are oil cups. The milk is delivered through the tube "b" and flows into a little bowl "d" from which it passes out into the large bowl "A" through an opening not shown in the cut. "C" and "D" are tin pans made to fit closely down over the separator bowl. "v" is the speed indicator for determining the number of revolutions per minute. After the machine has been started and attained a speed of over 6,000 revolutions per minute, the milk is let into the bowl through the cock "b" and assumes the position in the bowl in layers arranged according to specific gravity. If there be any sand or dirt in the milk, this will be held near the outside or the bowl; then comes the layers of skim-milk, and lastly, next to the center of the bowl, comes the layer of the cream. At this rate of speed, the separation of the milk after it passes from the bowl "d" is almost instantaneous. The skim-milk is forced by the centrifugal force through the tube "e" and out through an opening in the side of it at "c" where the skim-milk is caught in the pan "D" and delivered through the lower spout. The cream rises upon the inside of the bowl, and passes out through a little slit in the top of it at "f" into the cream pan "C" and the cream is delivered from the upper spout. The quantity of skim-milk thrown off may be regulated by a little screw in the bowl at "f" which opens and closes the aperture at "c." This machine works very perfectly and leaves little to be desired so far as the quality of the work is concerned. Several modifications of the principle of this machine have been introduced, but they refer principally to the method of supplying the power. This particular form of machine is sold by the *De Laval Separator Co.*, 74 Cortlandt st., New York City, or by any of their agents throughout the country. P. M. Sharpless, of West Chester, Pa., manufactures what he terms an "*Improved De Laval*," which is meeting with extensive sale in the country. The latter manufactures a steam turbine separator in which the power is applied by steam acting upon a small turbine wheel at the bottom of the separator stand. I have not seen the machine in operation and hence cannot state positively as to the efficiency of this form of application of power to it. The success of the separator depends largely upon having an unvarying source of power, and if left to the direct action of steam, it will be necessary for the steam pressure in the boiler to be maintained uniform to secure the highest efficiency unless some automatic arrangement is devised for regulating the flow of milk to the separator.

Hand Separators.

The DeLaval Company manufactures two forms of hand machines adapted to use of small dairymen: one an upright form and the other horizontal. The horizontal machine is represented in the above cut. Our experience with the upright machine has

Ftg. 2.



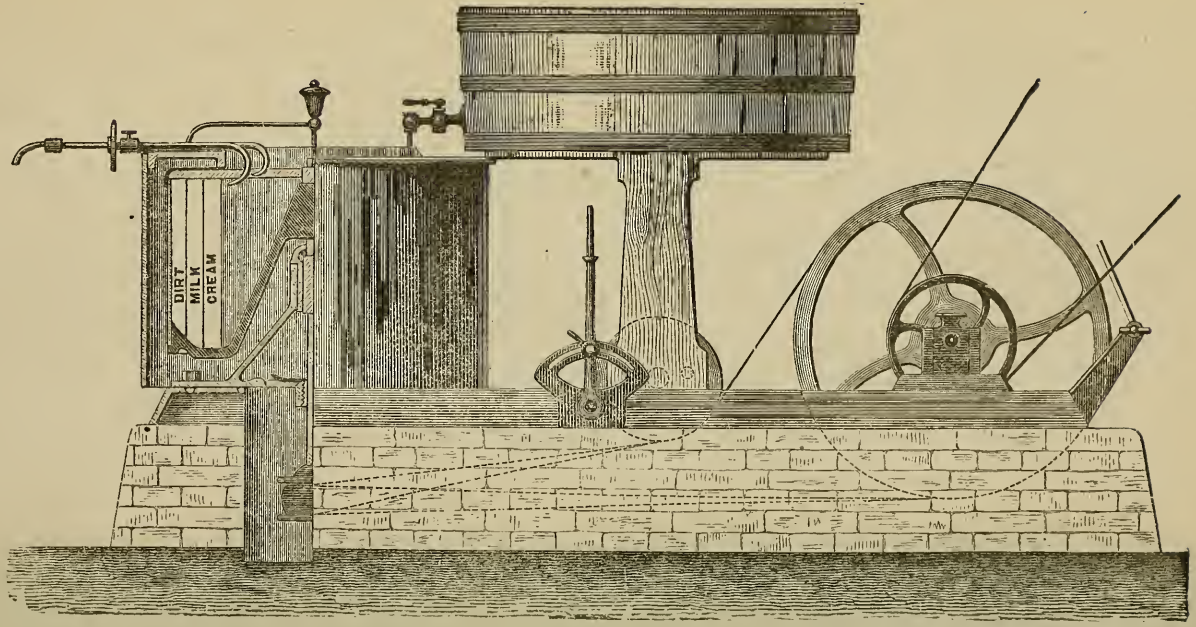
HORIZONTAL DELEVAL SEPARATOR.

been that it separates the cream satisfactorily; but the labor of turning the machine is very severe. The horizontal machine runs easier, and is said to do its work fully as satisfactorily. These hand machines will separate about 250 pounds of milk an hour.

The Danish Weston Separators.

The other machine prominently before the people is the "Danish Weston," a cut of which is herewith presented. The bowl of this machine is larger than that of the *DeLaval* and hence does not have to be run at such high speed. A study of the cut will show the manner in which the milk is separated in the bowl by centrifugal force. The cream stands next to the inside of the bowl and dirt next to the outside; while the skim-milk stands between the dirt and the cream. The cream is skimmed off by means of a tube set to catch it. As it rises in the cylinder, another tube is arranged so that it will catch the skim-milk and carry it off in another direction. These are provided with adjustments so that the quantity of milk taken with the cream can be changed to suit the wishes of the creamery-man at will. The "Danish Weston" will separate slightly sour milk. The "*DeLaval*" separator very soon becomes clogged when sour milk is run into it, and for this reason, some creameries prefer the "Danish Weston" machine; especially in sections where it is difficult or impossible to collect all of the milk at the creamery before it has begun to sour. This machine is, however considerably more expensive than the "*DeLaval,*" and skims no closer. It rests with the Creamery Company to determine which kind of machine is best adapted to its use. The Greenbrier Creamery in this State uses the "Danish Weston" machine and I understand is very highly pleased with it. Most of the other creameries of the State use the "*DeLaval*" or the "Sharpless Improved *DeLaval.*" The "Danish Weston" machine can be secured through the Creamery Package Manufacturing Company, 20 North Clark street, Chicago, or from A. H. Ried, Philadelphia. It can also be had through almost any of the dealers in creamery supplies.

There is but one other separator manufactured in this country so far as known to us that requires our attention, and that is the "Backstrom," which is a most excellent machine, and in some respects I believe it superior to either of the machines named. We have had one of these machines at the station here, and have been well pleased with it. The machine has a shelf in the bowl upon which the skim-milk is forced by centrifugal force, and it is there caught by a tube similar to the arrangement in the "Danish Weston." The cream passes out through an opening at the bottom of the bowl, and is delivered at the side of the stand. In size and capacity, the machine is not unlike the *DeLaval.* At present, however, the Backstrom Manufacturing Company of New York, which owns the patent, seems to be financially embarrassed, and I believe there are none of the machines upon the market; a matter, I think, that is to be regretted, as it was the cheapest machine offered in the American market, and in our judgement one of the best.

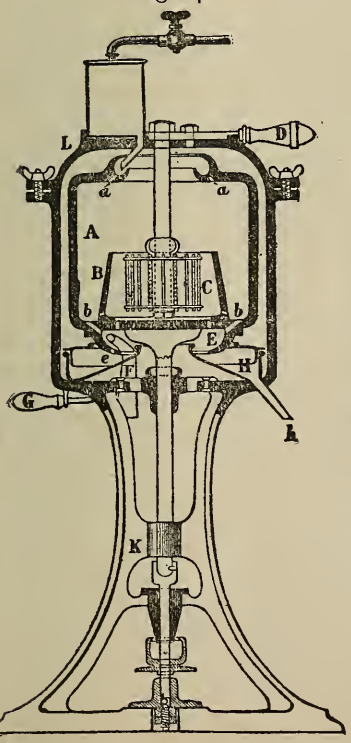


THE DANISH-WESTON SEPARATOR.

Recently, still another advance has been made in the separation of cream, and it is now proposed to extract the butter from the milk by means of centrifugal force. The chief difference between butter and cream is that the cream consists of the butter in a very finely divided condition held in suspension in a certain amount of liquid. The process of churning as ordinarily practiced causes the globules of fat in the cream to unite and form larger masses, so that most of the liquid can be drained off from them. Granulation of butter is nothing more than the aggregation of the small fat globules in the cream. Formerly it was supposed that in order to accomplish this, it was necessary to have the cream undergo a slight fermentation and become acid. The work at this Station during the past year indicates that this supposition is entirely without foundation, and by employing the proper means, we can secure as excellent a yield and as good quality of butter from sweet cream as from acid cream.

The butter extractor, which represents the farthest advance in the manufacture of butter by machinery, is the invention of C. A. Johansson of Stockholm, Sweden. Few of the machines have yet been placed upon the market in this country, and no doubt many improvements will be effected in it within the next few years; but the principle represents the highest advance in the handling of milk.

Fig. 4



A section of the machine is represented in the cut before us. It will be noticed that it is supported on a stand not very dissimilar from the stand of an ordinary separator; the machine being a little larger than the *DeLaval* separator. The machine is driven by a belt similar to the separator, by which the cylinder "A" is made to revolve at a speed of about 6,000 revolutions per minute. The internal construction of the cylinder is somewhat different from that of the separator. It will be noticed that it has an inside cylinder "B" which rises to about one-half the height of the larger cylinder. In the inside of this cylinder, is a trundle wheel "C" which also revolves with the machine, though at a less rate of speed. The machine is started, and after it attains the required speed, the milk is delivered through the small openings "aa" in the top, which throw the milk to the outside of the cylinder. This acting upon the principle of the cream separator causes the skim-milk to separate from the

cream and the skim-milk passes down through the openings "bb" and escapes through the opening "H." The cream drops into the inner cylinder "B" and is agitated by the trundle wheel "C;" the centrifugal force acting upon it causes the remainder of the liquid in the cream to take the outside of the cylinder, and it escapes through the small openings "bb" into the skim-milk, while the butter fat in a granulated condition drops through the openings into the chamber "E" where it is scooped up and carried off by the tube "F," a small portion of the skim-milk being allowed to accompany it so that it will move freely. The machine can be converted into a separator by withdrawing the trundle wheel; in which case, cream will be delivered through the tube "F" and the skim-milk through the tube "H."

The capacity of the machine is about 1,500 pounds of milk per hour. The milk may be either sweet or sour. It may be run as a separator and the cream kept until next day, and then as acid cream run through the extractor when acid cream butter is secured, or if sweet cream butter is preferred, one continuous operation does the work. Recent improvements in the machine provide an Automatic Feed Regulator, an Automatic Coloring Cup, and proper facilities for adjusting the quantity of color and the flow of the milk.

Observations upon Separation of Cream for November, 1889.

The following series of observations upon the separation of cream and churning were made before the butter extractor had been developed to its present stage of perfection. We are not yet sure that the butter extractor can be successfully used in this latitude without the expense of considerable ice, and we believe that the separator, for many years to come, will be the machine best adapted to the use of creameries in this latitude and countries farther south. In pursuing the series of observations which we herewith publish, we have endeavored, so far as our time and facilities would permit, to determine the conditions under which we could handle milk most economically and effectually, and also to determine the best methods of churning cream. At the end of each table of observations is given a summary indicating the most prominent points brought out by our observations. It was our expectation to continue the work, but circumstances over which we have had no control have forced us for the time being to discontinue the work, which we hope at some future time to take up and investigate a number of questions which this series of observations have raised in our own minds, and which may occur to other investigators upon studying our work. We publish it in the present form, however, without reservation, as we are still uncertain whether we shall be able to continue it.

	1	2	4	5	6	7	8	9	11	12	13	14
Pounds of milk handled	509	529	640	448	452	444	455	421	644	448	468	446
Av'rage fat contents (per ct.)	4.250	4.105	4.425	4.318	4.210	3.956	4.124	4.081	3.953	4.016	4.020	4.029
Pounds cream obtained	100	109	130	90	92	90	92	85	125	90	93	89
Specific gravity of cream												
Pounds of skim milk obt'ned	409	419½	510	358	360	354	362	336½	519	358	374	357
Specific gravity of skim milk												
Fat content of skim milk												
Temp. milk during separ't'n	80	81	80	80	80	82	80	80	80	81	75	80
Temp. of cream from sepa'tor	76	77	76½	76	76	79	76	76	76	77½	72	76
Temp. skim mk from sepe'tor	80	81	80	80	81	82	80	80	80	81	75	80
Speed of separator	6500	6500	6500	6500	6500	6500	6000	6000	6000	6500	6500	6500
Time of separation	35	36	38	31	30	30	31	30	38	32	32	30
Rate of sepa'ton pr hour in lbs	872.5	884.7	1010.5	867 1	904.0	888 0	880.6	842 0	1016 8	840 0	877.5	892.0

15	16	18	19	20	21	22	23	25	26	27	29	30
484	463	798	489	457	473	451	418	932	417	446	905	325
3.855	4.212	4.149	4.186	3 991	4.059	4.067	4.055	3.947	4.064	4.070	3.968	4.311
98	92	72½	100	82	79	84	70	163½	67	80	170	63½
.....	.....	.....	.....	1.0000	1.0060	1.0060	.....	1.0034	1.0090	1.0066	1.0135	1.0079
386	371	726	389	368	394	370	348	768	349	330	734	261
.....	.....	.....	1.0357	1.0345	1·0360	1.0360	.....	1.0340	1.0353	1.0353	1.0344	1.0368
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
78	80	80	84	84	86	84	84	82	85	84	86	84
75	76	76	80	79	82	80	80	79	81	80	81	80
78	80	80	84	81	86	84	84	82	85	84	84	84
6500	6500	6500	6500	7500	7500	7000	7000	7500	7500	7500	7500	7500
34	32	42	34	29½	31	28½	24	54	23½	24	60	20
854.1	868.1	1140 0	862 9	917.2	913.4	949. 4	1045 0	1035 5	1064.6	1365 0	905.0	975.00

Average of Observations Upon the Separation of Cream for the Month of November, 1889.

Average per cent. of butter fat in the milk, 4.097.

Average per cent. butter fat remaining in skim milk less than .1 of 1 per cent. (Our methods did not read closer than one-tenth per cent.).

Average quantity of milk handled per day, 511 pounds.

Average quantity of cream separated from the same, 96½ pounds.

Average per cent. of whole milk separated as cream, 18.88.

Average specific gravity of cream, 1.0065.

Average specific gravity of skim milk, 1.0352.

Average temperature of milk entering separator, 81.6 degrees.

Average temperature of cream coming from separator, 77.7.

Average temperature of skim milk coming from separator, 81.6.

The cream was cooled by the process of separation 3.9 degrees.

Average speed of separator, 6760.

Average time of separation, 33.18 minutes.

Average rate of separation per hour, 946.93 pounds.

It will be observed that the separator works perfectly at this rate of speed when the milk is at this temperature and delivered at the rate of about 950 pounds per hour. Where the percentage of fat found in skim milk was less than .1 of 1 per cent., it was marked a trace or as 0. Most of the determinations of the fat of skim milk made by the gravimetric method indicated from .02 per cent. to .05 per cent., and in some cases as high as .07 of 1 per cent., which all will recognize as being within the limits of error in chemical analysis.

Observations upon Separation of Cream for December, 1889.

	2	4	6	9	11	13
Pounds of milk handled	1006	1176	1121	1136	1125	1112
Average Fat content (per cent)	4.093	3.843	4.042	4.021	3.818	3.879
Pounds of Cream obtained	177	236	271	166	207	230½
Specific gravity of cream	1.0080	1.0117	1.0070	.....	1.0110	1.0118
Pounds of skim milk obtained	828½	940	849¾	961	977	881
Specific gravity of skim milk	1 0353	1.0351	1.0370	.....	1.0356	1.0355
Fat content of skim milk	.0	.0	.0	.0	.0	.0
Temperature of milk during separation	84	82	82	82	82	81
Temperature of cream from separator	80	78	78	78	78	77
T'mperat'e of skim milk from separator	84	82	81	82	82	81
Speed of separator	6500	6500	6500	6500	6500	6500
Time of separation	68	75	83	59	79	86
Rate of separation per hour	887.7	940 8	809.6	1155 2	854.4	776.7

16	18	20	23	24	26	28	30
1323	1045	963	1282	518	949	1019	1135
3 838	3.807	3.787	3.624	3 889	3.734	No test	3,695
204	.....	196½	202	87	139	192	208
1.0000	1.0148	1.0101	1.0090	1.0115	1.0000	1.0111	1,0121
1118	.....	767	1080	431	809	827	927
1.0352	1.0351	1 0354	1.0349	1.0351	1 0351	.....	1.0350
.0	.0	.0	.0	.0	.0	.0	.0
80	.....	80	80	80	80	78	80
76	.....	76	76	76	78	75	76
80	.....	80	80	80	80	78	80
6500	.....	6500	6500	6500	6500	6500	6000
95	.....	65	90	38	61	72	85
835.5	.....	888.9	854 6	817.8	933.4	849.1	801.7

Average of Observations upon the Separation of Cream for the Month of December, 1889.

Average quantity of milk handled per day, 938.8 pounds.

Average per cent. of butter fat in the milk, 3.855, making a decrease of butter fat content of the milk of December over that of November of .242.

Average per cent. of milk separated as cream, 19.80.

Average specific gravity of cream separated, 1.0090.

Average specific gravity of skim-milk, 1.0353.

Average temperature of milk entering separator, 80.84 degrees.

Average temperature of cream leaving separator, 77.07 degrees

Average temperature of skim-milk leaving separator, 80.84 degrees.

The cream during the process of separation being cooled, 3.77 degrees, against 3.90 degrees for November,

Average speed of separator per minute, 6461.

Average rate per hour at which milk was separated, 877.3.

Average fat content of skim-milk less than .1 of 1 per cent.

It will be observed that at this rate of separation, the speed of the separator being approximately 6500, and the temperature of the milk being approximately 80 & 1-2 degrees, the separation is completed to within the limits of error of chemical analysis. For this month, upon the average, about 1 per cent. more of skim-milk was taken out with the cream than for the month of November.

Observations upon Separation of Cream for January, 1890.

	1	3	6	8	10	13	15	17	20	22	24	27	29	31
Pounds of milk handled	954	1097	1437	1103	1090	1232	1088	1035	1507	1087	1092	1453	977	1062
Average fat content (per cent.)	No test	4 418	4.444	5.220	4.377	4.450	4.345	4.511	4.644	4.628	4.575	3 444	3.675	No test
Pounds of cream obtained	167	183	218	176	177	165	184	172½	236	196	205	290½	180	174
Pounds of skim milk obtained	787	914	1218	927	915	1067	904	863	1271	791	887	1163	797	886
Fat content of skim milk		.0	.0	.1	.1	.0	Trace	.0	.0	.0	.1	Trace	0	.2
Temperature of milk during separation	80	80	81	81	80	75	80	80	80	80	80	80	81	81
Temperature of cream from separator	76	76	76½	77½	77	73	76	78	76	76	77	77	79	79
Temperature of skim milk from sep'tor	80	80	80	80	80½	75½	80	81	80	80	81	80	81	81
Speed of separator	6000	6500	6500	6500	6500	7000	7000	6500	6500	6500	6500	6500	6500	6000
Time of separation	75	65	85	65	62	60	65	70	85	60	74	87	60	60
Rate of separation per hour	763.2	1012.6	1014.3	1015.1	1058.0	1232.0	1043.	887 1	1063.7	987.0	885.4	1002.0	977.0	1062.0

Average Observations upon the Separation of Cream for the Month of January, 1890.

Average quantity of milk handled per day, 1158 pounds.

Average per cent. of butter fat in milk, 4.394, being an increase in butter fat of .539 over that of December, and an increase of 0.297 over that of November.

Average per cent. of milk separated as cream, 16.97.

Average temperature of milk entering separator, 79.9 degrees.

Average temperature of cream delivered from separator, 76.7 degrees.

Average cooling of cream during separation, 3.2 degrees.

Average speed of separator 6500.

The average observations for the three months, November, December and January, indicate that the cream coming from the separator is cooled during the process of separation from 3.2 degrees to 3.9 degrees, having an average of 3.62 degrees. The skim-milk delivered from the separator has uniformly the same temperature as the milk entering the separator. The energy of separation is therefore expended upon the cream, which is converted into mist, giving it perfect aeration and depriving it during the process of separation of animal heat and animal odors contained in it, and its chemical composition is sufficiently changed to render it unadapted to the manufacture of the best quality of whipped cream without the use of some substance, like the white of an egg, to increase its adhesive powers.

The cream coming from the separator is undoubtedly the purest form of cream offered to the public, being deprived of its impurities and all foul odors that may have been absorbed by it.

It will be noticed that the separation for the month of January was not so perfect as during the two preceding months. The skim milk contained on several occasions as much as .1 of 1 per cent. and on one day as much as .2 of 1 per cent.

The rate of separation of the milk was 998.9 pounds per hour. The extreme variation maximum from this makes 1232 pounds per hour. Minimum 763.2 pounds per hour.

It would seem from the observations of this month that separation of milk is not perfect at revolutions of the separator below 6000 when the rate of delivery of milk is over 1000 pounds per hour. It would seem that the capacity of the machine had been reached, or at least that if the milk be fed to the machine rapidly at the rate of 1000 pounds per hour, there is likely to be a small residue of butter fat left in the skim milk, and yet, with the machine going at 7000 revolutions per minute, we succeeded in separating perfectly at the rate of 1232 pounds per hour. In one case where the machine was running at 7000 revolutions per minute, there was a small residue of butter fat in the skim milk when we were separating at the rate of 1043 pounds per hour. Our machine is rated at 850 pounds of milk per hour; but we have uniformly run it at a higher rate.

Observations upon Separation of Cream for February, 1890.

	3	5	7	10
Pounds of milk received	1336	983	979	1197
Temperature of milk separated	80	78	81	80
Temperature of cream out	76	76	78	76
Temperature of skim milk out	80	78	81	80
Pounds of cream separated	245	192	183½	212
Pounds of skim milk separated	1091	791	795	985
Loss in handling	.0	.0	.5	.0
Minutes separating	80	63	71	70
Condition of machinery	O. K.	O. K.	O. K.	O. K.
Speed of separator	6600	6500	6500	6000
Temperature of room	62	61	58	50
Rate of separation in pounds per hour	1002	936	827.3	1026

12	14	17	19	21	24	26	28
967	927	1231	913	623	1463	877	893
80	82	81	84	82	82	81	82
76	79	79	81	80	80½	80	82
80	82	82	84	83	83	82	84
140	133½	170	148	120½	249	161½	147
727	793	1061	764	502	1214	715	746
.0	.5	.0	.1	.5	.0	.5	.0
54	52	65	51	35	80	60	50
O. K.	O. K.	O. K.	O. K.	O. K.	O. K.	Off.	O. K.
6500	7000	7000	7000	7000	7000	6500	7000
54	60	62	55	46	61	60	64
1074.4	1069.6	1136.3	1074.1	1068	1097.2	877	1071.6

Average of Observations upon the Separation of Cream for the Month of February, 1890.

Average quantity of milk handled, 1032.4 pounds.

Average per cent. of the whole milk separated as cream 16.96.

Average temperature of milk at time of separation, 81 degrees.

Average speed of separator, 6716.

Average temperature of cream delivered from separator, 78.6 degrees.

Average time of separation, 60.9 minutes.

Average reduction of temperature of cream during process of separation, 2.4 degrees.

Average rate of separation per hour, 1021.6.

The speed of the separator this month ranged from 6500 to 7000 per minute.

During this month, the tests of the skim-milk showed in all cases less than .1 of 1 per cent. of butter fat in the skim-milk, and the observations are accordingly neglected in the table. Another line of observations was begun indicating the quantity lost in handling. It will be observed that on four days of the month, the loss amounted to .5 pounds. On 7 days there was no loss, and 1 day, there was a loss of .1 pound. This loss occurs principally in leakage around the lids of the separator or in the conveying pipes, and is scarcely appreciable. The observations upon the loss of milk in this case indicate simply that the Creamery-man was working with great care, as the variation in any two weighings might be nearly as large as that recorded ; but when the averages were taken for the different weighings during the day, the loss in handling to be accounted for was indicated by the figures given. It is apparent, therefore, that the loss in handling milk is this way in inappreciable.

Observations upon Separation of Cream for March, 1890.

	3	5	7	10	12
Pounds of milk received	1210	845	968	1222	920
Temperature of milk separated	80	80½	82	82	80
Temperature of cream out	77	77	80	78	79
Temperature of skim milk out	81	80	82	83	82
Pounds of cream separated	221	149	170	216	144
Pounds of skim milk separated	989	696	798	1004	776
Loss in handling				2	
Minutes separating	65	51	50	80	45
Condition of machinery	Off	O K	O K	O K	O K
Speed of separator	6500	7000	6500	7000	6000
Rate of separation per hour. Pounds	1116.9	994·1	1161.6	916.5	1226.6

14	17	19	21	24	26	28	31
846	1260	986	1011	1310	1030	1125	1418
82	80	82	82	82	80	80	80
80	76	80	80	80	78	78	78
83	80	82	83	82	80	81	82
151	238	194	165	246	189½	209	262
695	1022	791	846	1064	841	916	1156
		1			½		
45	82	55	65	72	55	62	77
O K	O K	O K	O K	O K	O K	O K	O K
7000	7000	6500	6500	6500	7000	6500	6500
1128	921.9	1075.6	933.2	1091.6	1123.6	1088.7	1104.9

Average of Observations upon the Separation of Cream for the Month of March 1890,

Average quantity of milk handled per day, 1088 pounds.

Average temperature of milk entering the separator, 80.9 degrees.

Average temperature of cream coming from the separator, 78.5.

Average reduction of temperature of cream by separation, 2.4.

Average time of separation, 61.81 minutes.

Average speed of separator, 6653.

Average rate of separation per hour, 1067.9 pounds.

Average quantity of cream separated, 196.5 pounds.

Average per cent of whole milk separated as cream, 18.6.

The skim-milk for this month showed no appreciable residue of butter fat upon the days it was tested. It is probable, however, that a larger per cent of butter fat was left in the skim-milk during this month than during the previous months when we were testing the skim-milk more closely. The loss in handling the milk, it will be seen, is scarcely appreciable. The machinery ran regularly except the first day of separation, when some difficulty appears to have arisen; the term "off" in the table being used to indicate that some slight trouble interfered for a time with the working of the machinery, such as the slipping of belts, irregularity in the working of the engine, or some trifling matter of that character. It is not to be supposed that a speed of 6500 or 7000 was maintained uniformly throughout the whole time of separation, as it is almost impossible to keep the engine running with sufficient regularity to hold the speed for an hour at this figure; but the Creamery-man, as the speed varies, must adjust the flow of milk to the separator to suit the speed. A man in the habit of directing his attention to the condition of the machinery during the process of separation will notice slight variations in the speed even without the aid of a speedometer.

Observations upon Separation of Cream for April, 1890.

	2	4	7	9	11	14	16	18	21	23	25	26	28	29	30
Pounds of milk received	1091	1189	1352	974	1202	1501	1388	1432	1803	1712	1509	866	1594	1112	1056
Temperature of milk separated	82	80	80	88	82	84	80	80	83	76	78	78	80	76	78
Temperature of cream out	78	78	80	86	79	82	78	78	80	74	76	76	78	75	76
Temperature of skim milk out	82	80	82	88	82	84	80	80	83	76	78	78	80	77	78
Pounds of cream separated	185	217	233	151	191	287	200	263	321	275	258	151	274	204	160
Pounds of skim milk separated	905	972	1119	822	1011	1210	1186	1168	1581	1436	1249	755	1318	908	896
Loss in handling	1	0	0	1	0	4	2	1	1	1	2	0	2	0	0
Minutes separating	63	67½	72	51	66	77	80	60	85	75	80	42	83	58	52
Condition of machinery	O K	O K	O K	O K	O K	.....	O K	O K	O K	O K	O K	O K	O K	O K	O K
Speed of separator	6500	6500	6500	6500	6500	6500	6000	7000	6500	6500	6500	6500	6000	6500	6500
Rate of separator per 100 pounds	1039	1056.8	1126.6	1146	1092.7	1169 6	1041	1432	1272.7	1369.6	1131.7	1237.1	1152.2	1150.3	1218.4

Average of Observations upon the Separation of Cream for the Month of April, 1890.

Average quantity of milk handled per day, 1319.3 pounds.

Average temperature of milk delivered to the separator, 80.3 degrees.

Average temperature of cream delivered from separator, 78.2 degrees.

Average reduction of temperature during process of separation, 2.1 degrees.

Average quantity of cream separated, 224.6 pounds.

Average per cent. of whole milk separated as cream, 17.2.

Average time of separation, 67.4 minutes.

Average speed of separator, 6466.

Average rate of separation per hour, 1175 pounds.

The tests of skim-milk during this month indicate that a small percentage of butter fat, still less, however, than .1 of 1 per cent. upon the average, remains in the skim-milk. The tests were not made daily, however, and the observations for that reason are not recorded in the tables published. It will be noticed that the wastage of milk in handling has increased to a certain extent; but still upon the average, it would make a very small fraction of 19790 pounds of milk handled during this month; the whole loss in handling the entire quantity being only 15 pounds.

The observations upon the separation of milk as practiced in this creamery for the period extending from November 1st, 1889, to May 1st, 1890, indicate that the best results are secured under the following conditions: The milk should have a temperature of from 80 to 82 degrees. The separator to run at a speed of from 6500 to 7000 revolutions per minute. The engine should be maintained at a constant rate of speed. The delivery of the milk should be uni form, and at a rate of 900 pounds per hour. About 18 per cent. of the whole milk should be separated as cream. We separated as cream from this period an average of 17.97 per cent. of the whole milk. It is doubtful whether the percentage of fat in the skim-milk is reduced by running 20 per cent. of the whole milk through the cream pan of the separator.

Observations upon Churning for November, 1889.

	2	3	4	5	6	7	8	9	11	12	14	14	14
Pounds of cream churned..	100	86	76	61	60				86	128			
Specific gravity of cream (observations under this head were not made until the 20th)													
Condition of cream churned	24 hrs. Acid	48 hrs. Acid.	Sweet.	Sweet.	Sweet.		hrs. 24 Acid.	hrs. 24 Acid.	hrs. 48 Acid.	hrs. 24 Acid.	hrs. 48 Acid.	hrs. 24 Acid.	Sweet.
Theoretical butter value	21.63	21.71	28.32	19.34	19.02		18.76	17.18	25.45	17.99	18.81	17.97	18.65
Actual yield of unworked butter	28	22	29	24	23		23½	18	31	34	25	24	18
Number lbs. of marketable butter	26	19	24	21	19		20½	13	25	31	20	22	15
Temperature of cream at starting	60	60	60	60	60		60	62	60	60	60	60	60
Temperature of cream at ending	62	62	62	62	62		62	64	62	62	62	62	62
Minutes required in churning	25	20	8	8½	18		15	15	18	20	19	20	12
Speed of churn	40	40	40	40	45		40	48	45	45	40	40	40
Pounds of water or ice used	0	0	0	0	0		0	0	0	0	0	0	0
Pounds of buttermilk obtained (observations not recorded until the 18th)													
Fat content of buttermilk							1.543	1.543	.0	.0	2.053	2.563	.0
Ounces of salt per pound of butter	1¼	1¼	1¼	Brine.	1¼		1¼	1¼	1¼	1¼	1¼	1¼	1¼
Number Drams of coloring used	10	8	7½	4½	8		10	7½	9	12	9	9½	6
Pounds of water worked out of butter (observations not recorded until the 18th)													
Pounds of cream after second separation			12	14	6								
Specific gravity of cream after 2d separation													
Butter from cream after 2nd separation	Acid B. M.	Acid B. M.	4	3½	Oz. 12		Acid B M.	Acid B. M.	Acid B. M.	Acid B. M.	Acid B. M.	Acid B. M.	8¼oz

Observations upon Churning for November, 1889—Continued

	18	19	19	20	21	22	23	25	27	27	29	30
Pounds of cream churned	72½	180	100	82	77	84	70	163	81	80	165	53
Specific gravity of cream (observations under this head were not made until the 20th)	.....	.....	.....	1.0000	1.0060	1.0060	.....	1.0340	1.0355	1.0353	1.0344	1 0368
Condition of cream churned	brs. 48 Acid.	hrs. 22 Acid.	Sweet.	Sweet.	Sweet.	Sweet.	Sweet.	Sweet.	hrs. 24 Acid.	Sweet	Sweet.	Sweet.
Theoretical butter value	19 50	33.10	20.46	17.99	19.19	18.34	15.44	36.78	16.94	22 22	35 91	14.01
Actual yield of unworked butter	26	46	23	27	22	22	29	52	32	30	63	13
Number lbs. of marketable butter	25	43	21	21	19¾	23	24	47	24	23	44	10-8 oz.
Temperature of cream at starting	58	60	64	64	61	59	57	56	58	59	50	53
Temperature of cream at ending	60	62	64	64	62	60	59	59	58	56	55	58
Minutes required in churning	27½	14	8	12	7½	7	11	9½	17	8	30	15
Speed of churn	45	35	35	35	37	40	35	40	40	40	40	40
Pounds of water or ice used	14	24	4½	2	30	5	4	20	10	0	30	20
Pounds of buttermilk obtained (observations not recorded until the 18th)	51	139	80½	55	58	60	49	122	59	57	138	36
Fat content of buttermilk	.0	1.747	.0	.....	.....	2.359	1.645	2.563	.0	3.481	Trace.	.0
Ounces of salt per pound of butter	1	½	½	1	1	1	1	1½	1¼	1¼	1¼	1¼
Number drams of coloring used	9	16	9½	10	9½	11	11	22	10½	10¼	22	7
Pounds of water worked out of butter (observations not recorded until the 18th)	Oz. 3-6½	.....	Oz. 2-8	Oz. 4-2	Oz. 3-3	.....	11	Oz. 11-8	Oz 8-7	Oz. 6-3	Oz. 12-6	Oz. 4-8
Pounds of cream after second separation	.....	.....	*	.....	.....	.....	.....	.....	.....	.....	.....	.....
Specific gravity of cream after second separation	.....	.....	1 0023	.....	.....	.....	.....	1.0167	.....	.....	.....	.....
Butter from cream after 2nd separation	Acid B. M.	Acid B. M.	Oz. 6-3	5	2	Oz. 1-8	0	4	Acid B. M.	Oz 1-4	0	8

*Cream from the second separation varied greatly as to its butter value, due to more or less milk necessarily introduced to start the flow of cream from the separator; hence the amount was not recorded, the object being to secure all of the butter fat.

Summary of Observations Upon Churning for November, 1889.

The churn used for this work was a 200 gallon Blanchard Rectangular churn, provided with a glass window for examining the cream during the process of churning, with an air valve for allowing the air or gas to escape.

In the churning of sweet cream, our method has been to take the cream that comes from the separator, cool as quickly as possible to the proper temperature, pour into the churn, and proceed with the churning without delay. The churning was done at from 35 to 48 revolutions per minute, average about 40. As soon as the butter assumed a granulated condition, the churn was stopped, the sweet buttermilk drained off and warmed to about 80 degrees and run through the separator. The cream secured from the second separation for experimental purposes, was churned separately; though in ordinary practice it can be churned with the cream secured from the separation of the next day. The butter secured in this form is in a perfectly granulated condition, may be washed and treated just as ordinary acid cream butter, with the exception that more salt is required for the sweet cream than for the acid cream butter. In the process of working the butter, the salt does not seem to be taken up by the sweet as readily as by the acid cream butter, and an additional quantity appears to be necessary to give the butter the customary degree of saltiness.

That this process of handling butter is expeditious may be illustrated by the fact that milk drawn from the cows in the morning and delivered at the creamery by eight or half past eight o'clock, was manufactured and printed into butter of the quality used upon the President's private table, and shipped before eleven o'clock of the same day.

The following figures for the month of November indicate what has been done.

Total butter-fat contained in the quantity of cream churned, as acid cream, 229.04.

Marketable butter secured from above amount of acid cream, 268.5.

An increase of total yield over test yield of, 39.40 pounds.

Per cent. of increased yield over test yield, 17.2.

Total quantity of butter-fat contained in cream churned as sweet cream, 285.67 pounds.

Marketable butter secured from the cream obtained by the first separation, 312.37 pounds.

Marketable butter secured from the cream derived from the second separation, 36.70.

Total marketable butter from sweet cream, 349.07.

Increase of actual marketable sweet cream butter over test yield, 63.40 pounds.

Per cent. of increase of yield of marketable butter over test yield, 22.1.

Average in yield in favor of churning sweet cream, 4.9 per cent.

Average time required to churn acid cream, 19.1 minute.

Average time required to churn sweet cream, 11.9 minutes.

Sweet cream was churned on the average of 7.2 minutes more quickly than acid cream.

Acid butter-milk at the end of churning varied in temperature from 58 to 64 degrees.

Sweet butter-milk at the end of churning varied in temperature from 55 to 62 degrees. Where there is little or no rise of temperature in the cream during churning of sweet cream, the residual fat in the butter-milk appears to be larger in some cases than where considerable rise of temperature is apparent.

Observations upon Churning for December, 1889.

	2	4	6	9	11	13	16	19	20	23	24	26	28	30
Pounds of cream churned	177	236	271	166	198	265	204	245	139	202	87	118	172	207
Specific gravity of cream	1.0353	1 0351	1.0370	....	1.0356	1.0355	1 0352	1.0357	1.0354	1.0349	1.0351	1.0357	.....	1.0350
Condition of cream churned	Sweet	Sweet	Sweet	Sweet	Sweet	Sweet	Sweet	24 hrs. Acid	Sweet	Sweet	Sweet	Sweet	Sweet	Sweet
Theoretical butter value	41.17	45.25	45.31	45 67	42.95	43 13	51 04	39 78	36 46	46.45	20.14	35 71	No. test	41 93
Actual yield of unworked butter	67	65	65½	46	58	59	81	58	58	72	27	42	55	56
Number pounds of marketable butter	50-6	54-2	55 12	36-10	49	50	57 8	50	44.14	52-10	22-8	32-8	45-9	44 13
Temperature of cream at starting	56	56	54	62	54	52	60	60	53	56	59	59	55	55
Temperature of cream at ending	59	58	57	62	57	55	63	61	58	55	58	60	57	58
Minutes required in churning	181½	29	24	10	24	30½	12	15	22	18	7½	8	19	20
Speed of churn	40	40	40	40	40	42	40	40	40	40	40	40	40	40
Pounds of water or ice used	0	32	36	0	0	0	37	0	0	0	1	0	10	0
Pounds of buttermilk obtained	129	203	206	120	140	143	127	190	89	127	60	81	130	137
Pounds of fat content of buttermilk	1.543	1.339	Trace	.....	1.339	1.339	2.665	Trace	1.543	1.747	3.175	3 583	.....	1.849
Ounces of salt per pound of butter	1¼	1⅜	1⅜	1⅜	1½	1½	1½	1½	1½	1⅝	1⅝	1¾	2	1½
Number of drams of coloring used	25	26	25	21	23	25	27	23	21	26	11	20	21	23
Pounds of water worked out of butter	18	10 8	8-8	8-10	10-8	14-12	23-4	12-8	15-12	20-08	7-4	10	13	10
Butter from cream from 2nd separation	0	0	oz. 14½	oz. 8-8	0	oz. 1-4	oz. 3 15	oz. 1-3½	oz. 1-11½	oz. 1-13	oz. 2-11½	oz. 6-13¾	oz. 3-6½	 0
Per ct. of fat of buttermilk from cream from 2nd separation	1.543	1.339	Trace*	Trace	Trace	Trace	1.543	Trace	.....	.....	Trace	Trace	.....	.....

*By trace we mean less than 1-10 of one per cent but over .05 per cent.

Summary of Observations upon Churning Sweet Cream for December, 1889.

Total amount of cream churned, 2627 pounds.

The test value of the cream churned as sweet cream was 495.21, pounds.

Produced unworked butter, 751.5, pounds.

Marketable butter from first separation, 601.37, pounds.

Salt water worked out of butter in excess of salt added, 50.13.

Per cent. of increase of marketable butter over the butter fat contained in the cream from first separation, 21.4 pounds.

Marketable butter secured from second separation 32.32, pounds.

Added to that from first separation gives 633.69 pounds.

It required to make one pound of marketable butter 4.14 pounds of cream.

The total gain of marketable butter over test yield butter fat was therefore, 27.9 per cent.

We observe that in all cases in the churning of sweet cream, there is a rise of temperature in the cream during process of churning ranging from 1 to 3 degrees when churning is done at temperatures from 52 to 60 degrees. There appears to be no rise of temperature when churning at 62 degrees; but a very large proportion of the butter fat remained in the cream to be secured by the second separation. The best results in churning sweet cream this month were secured where the temperature of the cream arose about 3 degrees during the process of churning. In three cases, all butter being so fully secured that even the separator failed to extract any significant amount of butter fat from the sweet cream butter-milk. The demands of our customers require the use of from 1½ to 2 ounces of salt to a pound of unworked butter. The reason for this is not clear to us at present; but sweet cream butter having from 1½ to 2 ounces of salt added to it has about the same degree of saltiness as acid cream butter containing from 1 to 1½ ounces of salt.

Observations upon Churning for January, 1890.

	2	3	6	9	10	13	15	17	20	23	24	27	29	31
Pounds of cream churned	167	180	203	176	137	149	184	172½	236	195	187	206	180	176
	hrs. 24			hrs. 24						hrs 24			hrs. 24	
Condition of cream churned	Acid.	Sweet.	Sweet.	Acid	Sweet.	Sweet	Sweet	Sweet.	Sweet.	Acid.	Sweet.	Sweet	Acid.	Sweet.
Test--butter-fat value	.....	48.46	63 86	57 57	47.80	54.82	47 27	46.68	69.98	45 67	49 95	50.04	35 90	.....
Actual yield of unworked butter	56	60	72	60	47½	44½	52½	58½	82	58	54	56	60	55
Number pounds of marketable butter	49	51	70	57	47	52	50	58	75	49	48	46	52	50
Temperature of cream at starting	58	50	54	62	42	45	58	42	52	53	54	56	62	49
Temperature of cream at ending	60	54	56	63	52	56	61	52	54	60	56	58	60	5[illegible]
Minutes required in churning	24	22	19	16	37	18	30	45	24	52	19	20	12	17
Speed of churn	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Pounds of water or ice used	20	25	80	.....	34	24	.....	39	40	16	15	25	12	30
Pounds of buttermilk obtained	88	94	107	120	94	93	127	111	150	133	113	151	105	116
Fat content of buttermilk	.4	.2	6	.....	.0	2	.4	.0	.7	.3	.3	.2	.....	.2
Ounces of salt per pound of butter	2	2	2	2	2	1¾	1½	1½	1½	1½	1½	1½	1½	1½
Number drams of coloring used	20	22	29	22	22	21	22	21	30	20	22	26	16	18½
Pounds of water worked out of butter after second separation	11-8	11-8	13	9-8	7-8	8	4-4	3-4	13-12	2-4	7-8	11	11-8	7-8
Specific gravity of cream after 2d separation	.....	.....	1.0283	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Acid	oz	oz	Acid.			oz.			Acid.	oz.	lb.	Acid	oz
Butter from cream after second separation	B. M.	8	1-13	B. M.	.0	.0	1-1	.0	.0	B. M.	15½	1	B. M.	6
Per cent of fat of buttermilk from cream after second separation	.0	.0	.....	.....	.0	.0	Trace.	.0	.0	.....	.0	.1	.....	.....

Summary of Observations upon Churning for January, 1890.

Total sweet cream churned, 1830.5 pounds.
Total acid cream churned, 718 pounds.
Test value of sweet cream churned, 478.86 pounds.
Test value of acid cream churned, 139.14 pounds.
Yield of unworked sweet cream butter, 527 pounds.
Yield of unworked acid cream butter, 178 pounds.
Marketable butter secured from sweet cream, 497 pounds.
Marketable butter secured from acid cream, 157 pounds.
Per cent of gain of marketable butter over test value of sweet cream butter, 4.9.
Per cent of gain of marketable butter over test value of acid cream, 13.5.
It required 3.68 pounds sweet cream to make one pound of butter.
It required 4.57 pounds of acid cream to make one pound of butter.
Average temperature of sweet cream at beginning of churning, 50.3 degrees.
Average temperature of sweet cream at ending of churning, 55.4 degrees.
Rise of temperature during churning of sweet cream, 5.1 degrees.
Average temperature of acid cream at beginning of churning, 59 degrees.
Average temperature of acid cream at end of churning, 61 degrees.
Average fat content of butter-milk from sweet cream 0.26 per cent.
Per cent of weight of unworked sweet cream butter worked out as salt water, 15.1.
Per cent of weight of acid cream butter worked out as salt water, 13.

Observations upon Churning of Sweet Cream for February, 1890.

	4	5	7	10	12	14	17	19	21	24	26	28
Temperature of cream	64	62	52	48	46	48	64	45	38	51	50	46
Hours after separation	24	0	0	0	0	0	0	0	0	0	0	0
Pounds of cream churned	242	192	165	169	110	133½	170	124	70	241	161	139
Pounds of water added	25	30	25	30	20	27	57	35	2	45	30	30
Temperature of water	Ice	Ice	Ice	Ice	Ice	Ice	45	Ice	Ice	Ice	Ice	Ice
Revolutions of churn per minute	40	40	40	40	40	40	40	40	40	40	40	40
Number of drams of coloring	24	18	16	16	12	16	8½	12	6	22	13	12
Ounces of salt per one pound of butter	1½	1¼	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
Minutes churning	9	13	22	33	18	16	21	29	43	27	22	15
Minutes draining butter milk	15	15	15	30	30	20	20	20	20	30	20	20
Minutes draining wash water	20	20	20	40	20	20	20	20	20	20	20	20
Pounds of butter milk	182	152	135	107	72½	104	118	95	47	158	117	95
Temperature of butter milk at end of churning	66	63	54	51	52	54	66	53	50	55	55	54
Pounds of butter before working	65	36½	57	50	39	52	55½	35¾	21	79½	44	40½
Pounds of butter after working	58	30¾	41¾	42¼	33½	42½	50½	36	18½	68½	42½	40½
Pounds of salt water worked out	11¼	7	10¾	7¼	6¼	12	9	2¼	3¼	14½	5	3
Temperature of worked butter	56	54	54	54	2	52	54	54	54	54	56	58
Pounds of cream from second separation	20	24	14	0	0	0	21	0	0	12	8	13
Pounds of butter from cream after second separation	lbs oz 2 9	lb oz 1 8	oz 7½	0	0	0	lbs. 6	0	0	oz 6	0	oz 14

Summary of Observations upon Churning of Sweet Cream for February, 1890.

Total cream churned, 1916.5 pounds.
Average time of churning, 22⅓ minutes.
Average temperature at beginning of churning, 51 degrees.
Average temperature at end of churning, 56 degrees.
Increase of temperature by churning, 5 degrees.
Unwashed butter secured, 575.75 pounds.
Marketable butter secured, 505.25 pounds.
Salt water worked out of butter, 91.75.
Salt water worked out is equal to 15.9 per cent. of the unworked butter before the addition of the salt.

It required 3.79 pounds of cream to make one pound of marketable butter.

It will be noticed that during this month, we churned at temperature as low as 45 degrees; but in no case was the churning completed at a temperature lower than 51 degrees. It will be further noted, that by churning at the low temperature below 50 degrees, substantially all of the butter can be secured from sweet cream without employing the second separation.

Observations Upon Churning for March, 1890.

	3	5	7	10	12	14	17	19	21	24	26	28	31
Temperature of cream	49	45	42	48	48	56	50	48	48	42	48	46	41¾
Hours after separation	0	0	0	0	0	0	0	0	0	0	0	0	0
Pounds of cream churned	218	149	160	216	128	138½	224½	179	156½	230	189½	204	270
Pounds of water added	35	30	35	40	30	25½	36	31	30	50	35	40	58
Temperature of water	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice
Revolutions of churn per minute	40	40	40	40	40	40	40	40	40	40	40	40	40
Number of drams of coloring	18	12	12	19	12	12	18	12	15	18	15	16	20
Ounces of salt per 1 lb. of butter	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
Minutes churning	29	33	63	45	28	50	37	5	25	80	20	30	100
Minutes draining butter milk	20	20	20	20	20	20	20	20	20	20	20	20	20
Minutes draining wash water	20	20	20	20	60	20	20	20	20	20	20	20	20
Pounds of buttermilk	147	97	109	142	87	90	160	134	107½	166	133	150	180
Temperature of butter at end of churning	54	53	54	54	54	52	56	54	54	52	52	52	53
Pounds of butter before working	62	45	49	70½	38½	37	63½	50½	46	61	52	57	71
Pounds of butter after working	56½	40½	43½	59	59	34	55½	43	44½	58¼	46	53	63
Pounds of water worked out of butter	9	8	4½	15	2½	3	9	9½	4½	6½	8½	9	11
Temperature of worked butter	48	50	50	52	56	54	52	52	56	50	52	52	50
Pounds of cream from second separation	10	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Summary of Observations upon Churning for March, 1890.

Total amount of cream churned, 2460 pounds.

Average temperature at beginning of churning, 44.4 degrees.

Average temperature of butter-milk at the end of churning, 50.8 degrees.

Increase of temperature by churning, 6.4 degrees.

Average time of churning, 41 minutes.

Unworked butter obtained, 827.75 pounds.

Marketable butter secured, 783.75 pounds.

Salt water worked out, 86 pounds.

Per cent. of unworked butter passing off as salt water, 10.3 pounds.

Average temperature at which the butter was worked, 53.5 degrees.

Amount of cream necessary to produce one pound of marketable butter, 3.15 pounds.

By churning at the low temperature indicated, it was found that the butter could be very perfectly extracted from the sweet cream, and the process of a second separation was abandoned. Our Creamery-man stated that no appreciable amount of cream could be secured from the sweet cream butter milk by running it through the separator after churning at temperatures ranging from about 42 to 50 degrees. It will be noticed further, that we determined upon 1½ ounces of salt as the amount best adapted to the tastes of our customers.

Observations upon Churning for April, 1890.

	2	4	7	9	11	14	16	18	21	23	25	26	28	29	30
Temperature of cream at churning	48	46	46	48	42	42	38	42	42	50	46	40	46	43	47
Hours after separation	0	0	0	0	0	0	0	0	0	*0	0	†0	0	0	0
Pounds of cream churned	181	214½	232½	139	190	274½	191½	217	241	274	217	59	257	180	136
Pounds of water added	35	48	47	30	41	52½	50	49	52½	47½	41	14	45	35	24
Temperature of water	Ice	Ice	Ice	I e	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice
Revolutions of churn per minute	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Number of drams of coloring	16	17	20	15	16	20	16	16	15	20	16	5	16	10	8
Ounces of salt per one pound of butter	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
Minutes churning	30	35	36	20	41	45	60	55	55	79	34	21	37	45	22
Minutes draining buttermilk	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Minutes draining wash water	20	80	20	20	120	20	20	20	20	20	20	20	20	20	20
Pounds of buttermilk	124	154	165	109	126	207	124	160	176	383	150	61	187	132	105
Temperature of buttermilk at end of churning	52	53	50	56	48	48	46	52	48	57	51	46	52	50	53
Pounds of butter before working	51	56	63	39	57½	70	62	54¾	65	78	61½	20½	67	45	37½
Pounds of butter after working	49	55	60¼	40	53¾	61¼	60	52	62	70½	54	212	64½	41	37½
Pounds of water worked out of butter	4	5½	6¼	3	5	10½	6	4	5½	6¾	11¼	¾	6¾	6¾	4
Temperature of worked butter	52	53	55	56	53	53	52	54	53	53	52½	56	54	50	50

*192 pounds of sour milk churned with cream of 23d.
†24 pounds of sour cream mixed with churning.

Summary of Observations upon Churning for April, 1890.

Total sweet cream churned, 2671.

Rejecting the two days upon which acid cream was churned, we have average temperature at beginning of churning, 44.3 degrees

Average temperature at end of churning, 50.6 degrees.

Rise of temperature during churning, 6.3 degrees.

Total cream churned, 2671 pounds.

Average time of churning, 39.6 minutes.

Unworked butter secured, 729.25 pounds.

Amount of marketable butter secured, 692.25 pounds.

Amount of salt water worked out of butter, 78.50 pounds.

Per cent of unworked butter worked out as salt water, 10.7 pounds.

Number pounds of sweet cream necessary to make 1 pound of marketable butter, 3.85.

The butter for this month was worked very dry containing when delivered to the customers upon the average about 10 (9.71) per cent of moisture.

Observations upon Churning for May, 1890.

	1	2	3	6	7	8	9	9	10	12	13	14	15	16	17	19	20	21	22	23	24	26	27	28	29
Temperature of cream	40	35	48	60	52	62	62	46	...	...	...	...	62	60	60	57	58	62	62	62	64	60	60	57	60
	S†	S	S	S	S	S	S	S	...	...	...	...	A‡	A	A	A	A	A	A	A	A	A	A	A	A
Hours after separation	0	0	0	24	24	24	24	0	...	...	...	...	24	24	24	48	24	24	24	24	24	48	24	24	24
Pounds of cream churned	142	104	139½	264	200	203	189	76	...	...	...	...	210	202	232	218	366	281	274	278	248	264	278	253	252
Pounds of water added	37	25	20	15	20	0	50	10	...	...	...	...	20	10	12	10	13	2	6	13	7	20	20	20	0
Temperature of water	Ice	Ice	Ice	Ice	Ice	Ice	.....	Ice	...	...	...	...	.....	Ice	I ce	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice
Revolutions of churn per minute	40	40	40	40	40	40	40	40	...	...	...	...	40	40	40	40	40	40	40	40	40	40	40	40	40
Number drams of coloring	8	5	7½	14	10	10	8	3	...	...	...	...	10	12	20	10	16	12	12	12	12	12	12	11	10
Ounces of salt per pound of butter	1½	1½	1½	1½	1½	1½	1½	1½	...	...	...	...	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
Minutes churning	39	60	31	25	30	13	10	16	...	...	...	...	8	12	22	19	20	22	15	20	13	15	15	20	16
Minutes draining buttermilk	20	20	20	20	20	20	20	20	...	...	...	...	20	20	20	20	20	20	20	20	20	20	20	20	20
Minutes draining wash water	20	20	20	20	20	20	20	20	...	...	...	...	20	20	20	20	20	20	20	20	20	20	20	20	20
Pounds of buttermilk	140	81	95½	87	150	149	150	62	...	...	...	...	150	155	180	140	270	207	202	230	190	187	170	135	180
Temperature of buttermilk at end of churning	52	48	58	62	54	63	63	53	..	..	...	...	64	62	62	59	60	64	64	65	65	62	63	60	62
Pounds of butter before working	38	28	39½	79	58	54	49	19	...	..	...	...	57	60	60	52	91½	66½	73	73	52	74	72	71	62
Pounds of butter after working	35¼	26	33	74	58½	53	6 3	.....	...	...	...	...	52	59	60	52	91½	66½	73	73	52	74	72	71	62
Pounds of water worked out of butter	4	5½	3	10	3½	4¼	5½	.....	...	...	...	...	7	3½	3½	4	2½	3	3½	4	2½	2½	3	4	3¼

†Sweet. ‡Acid.

Summary of Observations upon Churning for Month of May, 1890.

Average temperature of sweet cream at beginning 50.6 degrees.

Average temperature of sweet cream at end of churning 56.6 degrees.

Increase of temperature by churning, 6 degrees.

Average time of churning 28 minutes.

Unworked sweet cream butter secured, 364.5 pounds.

Marketable sweet cream butter secured, 343.25 pounds.

Salt water worked out, 36 pounds.

Per cent. of unworked sweet cream butter worked off as salt water, 9.8.

Average temperature of acid cream at churning, 60.3 degrees.

Average temperature of acid cream at end of churning, 62.4 degrees.

Increase of temperatue by churning, 2.1 degrees.

Average time of churning acid cream, 16.6 minutes.

Unworked acid cream butter obtained, 8.64 pounds.

Marketable acid cream butter obtained, 858 pounds,

Pounds of salt water worked out, 48.25 pounds.

Per cent. of unworked butter worked out as salt water, 5.5.

It required 1317½ pounds of sweet cream to make 343¼ pounds of marketable butter, or 3.83 pounds of sweet cream produced 1 pound of marketable butter. It required 3356 pounds of acid cream to produce 858 pounds of marketable butter, or 3.91 pounds of cream to make I pound of marketable butter, supposing the cream to be uniform which it probably was. It required nearly 1-10 pounds more cream to produce 1 pound of acid cream butter, than to produce 1 pound of sweet cream butter.

Observations upon Churning for June, 1890.

	2	3	4	5	6	7	9	10	11	12	13	14	16	17	18	19	20	21	23	24	25	26	27	28	30
Temperature of cream	58	60	62	64	56	56	64	58	58	...	56	56	58	62	54	51	56	54	58	64	60	68	60	58	58
Hours after separation	48	24	24	24	24	24	48	24	24	...	24	24	48	24	24	24	24	24	48	24	24	24	24	24	48
Pounds of cream churned	28	292	236	240	197	70	163	267	100	...	.....	181	167	218	163	167	200	204	207	238	173	301	225	232	267
Pounds of water added	20	20	28	24	30	10	15	20	12	...	46	20	18	20	20	20	20	20	20	20	20	30	21	23	30
Temperature of water	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice	...	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice	Ice
Revolutions of churn per minute	40	40	40	40	40	40	40	40	40	...	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Number drams of coloring	10	10	10	10	8	4	8	12	5	...	14	8	8	8	8	8	9	6	9	8	8	9	8	8	8
Ounces of salt per one pound of butter	1½	1½	1½	1½	1½	1½	1½	1½	1½	...	1½	1½	1½	1	1	1	1	1	1	1	1	1	1	1	1
Minutes churning	15	18	11	11	9	10	10	20	13	...	30	20	13	10	13	15	12	9	12	10	9	15	13	15	16
Minutes drawing butter-milk	20	20	20	20	20	20	20	20	20	...	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Minutes drawing wash-water	20	20	20	20	20	20	20	20	20	...	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Pounds of butter-milk	148	220	160	164	120	40	115	170	70	...		142	115	140	125	120	150	135	115	170	100	210	176	172	200
Temperture of butter-milk at end of churning	59	64	64	64	58	58	62	60	60	...	.....	..	.....	61	56	58	56	56	60	66	62	60	62	60	60
Pounds of butter before working	58	72½	68	64½	62	22	46	78	34	...	113	67	62	78	52	56	71	68	61	66	58	85	55	60	55
Pounds of butter after working	58	76	69	64	63	22	41½	72	33	...	113	67	64	68	50	58	76	70	68	58	60	86	57	60	57
Pounds of water worked out of butter	2½	2½	2	3	2½	1	7	8	2	...	4	8	3	10	2	3	2	3	2½	2	2½	2	1	3	3½

Summary of Observations upon Churning Acid Cream, June, 1890.

Rejecting the days on which imperfect observations were made, we have the average temperature of cream at starting, 58.8 degrees.

Average temperature of cream at end of churning, 60.4 degrees.

Average rise temperature in churning acid cream, 1.6 degrees.

Total amount of acid cream churned, 4,729 pounds.

Average time of churning, 13 minutes.

Total amount of unworked butter obtained, 1,399 pounds.

Total amount of marketable butter obtained, 1,397½ pounds.

Total amount of salt water worked out, 78 pounds.

Per cent. of marketable butter worked off as salt water, 5.5.

Amount of acid cream necessary to produce 1 pound of marketable butter, 3.38 pounds.

The butter for this month was worked with a view of retaining within it as much moisture as possible. It appears to be the practice at some creameries to try to leave as large a quantity of water in the butter as possible, and this excess of water is sold as part of first-class creamery butter. It will be noticed that we have succeeded in this case, in producing marketable butter the weight of which was almost equal to the weight of the unworked butter. We do not believe that such a grade of butter as that manufactured during this month, ranging in all cases below 80 per cent. of butter fat, should be adopted as a fair, honest, butter. However, until a butter standard is established, we presume that dairy-men will continue to sell butter largely saturated with water. It is only a question of a little tact in the salting and working of butter to reduce the quantity of butter fat by the addition, or rather by the failure to work out the water, several per cent. It makes no difference whether the Creamery-man be working with acid or sweet cream butter, so far as the permitting of this adherent water to remain in the butter, is concerned.

The quality of the sweet cream butter is shown by the table of analyses following. The variation in the curd and salt contents is due to experimental work, and would not occur in ordinary dairy practice where a regular system is followed. It will be noticed that in all cases the standard of the butter was much above what is considered average quality of butter so far as fat content is concerned.

The averages of the churnings of acid cream and sweet cream for the period beginning November 1, 1889 and closing June 30, 1890, show that it required 3.95 pounds of acid cream to make 1 pound of butter and 3.74 pounds of sweet cream to make 1 pound of butter.

The observations for separating cream and for churning milk were taken by Mr. A. C. Magruder, the Creamery-man of the station; but the Director is responsible for the system of observations, the averages and conclusions.

Analyses of Sweet Cream Butter.

Kind.	Date.	Butter Fat.	Water.	Curd.	Ash.
Sweet	March 3	80.92 per cent	7.432 per cent	6.84 per cent	4.8 per cent
Sweet	15	79 984 per cent	9.94 per cent	5.752 per cent	4 424 per cent
Sweet	21	88.964 per cent	7.708 per cent	.616 per cent	.27 per cent
Sweet	22	80.108 per cent	12.82 per cent	.1412 per cent	5 66 per cent
Sweet	24	83.67 per cent	10 464 per cent	.76 per cent	5.1 per cent
Sweet	24	84.78 per cent	10.01 per cent	.1048 per cent	4 16 per cent
Sweet	27	87.496 per cent	11.08 per cent	.68 per cent	.74 per cent
Sweet	27	87 124 per cent	11.372 per cent	.624 per cent	88 per cent
Sweet	28	83.728 per cent	10.464 per cent	2.05 per cent	3 76 per cent
Sweet	28	83 22 per cent	10.46 per cent	1.7 per cent	4.62 per cent
Sweet	April 1	86.812 per cent	9. per cent	.568 per cent	3 62 per cent
Sweet	1	87.38 per cent	8.12 per cent	.88 per cent	3.62 per cent
Sweet	3	82.55 per cent	8 912 per cent	.88 per cent	2 64 per cent
Sweet	3	87 132 per cent	9.1 per cent	1. per cent	2.76 per cent
Sweet	5	85.396 per cent	9.052 per cent	1. per cent	4.37 per cent
Sweet	5	84.644 per cent	9.864 per cent	1.02 per cent	4.464 per cent
Sweet	7	82 22 per cent	9.636 per cent	1.15 per cent	6.99 per cent
Sweet	7	83.66 per cent	8.46 per cent	1.05 per cent	6.82 per cent
Sweet	8	81.888 per cent	10.328 per cent	.72 per cent	7.08 per cent
Sweet	8	82.064 per cent	11.78 per cent	95 per cent	5.2 per cent
Sweet	10	86.092 per cent	9.208 per cent	8.768 per cent	1.92 per cent
Sweet	10	87.28 per cent	8.852 per cent	.58 per cent	3.7 per cent
Sweet	12	85.62 per cent	8.256 per cent	5.412 per cent	.712 per cent
Sweet	15	88.04 per cent	9.288 per cent	1.56 per cent	1.104 per cent
Sweet	15	87.228 per cent	9.912 per cent	.696 per cen	2.1 per cent
Sweet	17	86.244 per cent	10.268 per cent	1.74 per cent	2.54 per cent
Sweet	17	85.8 per cent	10.62 per cent	.....	.....
Sweet	19	84.312 per cent	12.76 per cent	1.2 per cent	1.728 per cent
Sweet	19	84.656 per cent	12 18 per cent	.856 per cent	2.3 per cent

The Method of Analysis of Butter.

The method of analysis of butter adopted in making the following determinations was proposed by Dr- E. H. Jenkins of the Connecticut Experiment Station. The duplicate analyses show the difficulty in securing perfectly uniform samples of butter for analysis. In these analyses, the butter was not melted before weighing; the sample being drawn from the butter as finished ready for marketing.

Taking of Sample.

Take a piece of combustion tubing and force it into the butter at different points until a sufficient sample is obtained. This may be forced out of the tube by means of a close fitting cork pushed by a rod or stick.

For Moisture.

Weigh out accurately 2.5 grms. of the butter, and dry at temperature of boiling water until constant weight is secured. This is best done in a dish with a flat bottom of 3 or 4 square inches surface. It will generally be completed in from two to three hours, though heating for a longer time does not appear to change the weight either by loss or oxidation. Neither does heating it to 105 degrees C. appear to change the result.

Fat, Curd and Ash.

The dried butter from the water determination is treated in the dish with 76 degree benzine and stirred till the lumps disappear. It is then filtered on a weighed Gooch crucible. In order to secure complete extraction with a small quantity of benzine, after bringing on to the crucible, the latter is filled and allowed to empty without the use of suction until all fat is removed. Finally it is dried on the pump and then kept at 100 degrees C. for two hours and weighed. This weight less the weight of the crucible represents the curd and ash, and the difference between this and the dried butter represents the fat. The crucible is then heated below a red heat till its contents have burned white, and weighed again. The loss of weight is curd. The ash remains in the crucible. If dissolved, this may be removed by washing, and the salt determined by titration with Ag N O 3. The sample should be kept in a cool place.

Churn Test of Milk.

It has been claimed that the churn was the only test that could be relied upon in determining the value of milk, and in order to arrive at some idea of the reliability to be placed upon the churn test, he following churn tests were made under conditions as uniform as it is possible to make them :

Date 1889	Amount pounds.	Per cent. Fat.	Temp. Churned.	Condition.	Butter produced.	Butter produced per 100 lbs. milk.
Dec. 2	10	3.787	60 deg	Overchurned..	6 oz	60 oz
" 2	10	3 787	60 "	Granules	5½ oz	55 oz
" 4	13	3.583	60 "	Overchurned..	8 oz	61.5 oz
" 4	13	3.583	60 "	Granules	7¾ oz	59.6 oz
" 6	9	3 787	60 "	Overchurned	5½ oz	61.1 oz
" 6	9	3.787	60 "	Granules	5⅞ oz	63.8 oz
" 9	19	4.093	60 "	Overchurned	14 oz	73.6 oz
" 9	19	4 093	60 "	Granules	13 oz	68.4 oz
" 11	14	3.787	60 "	Overchurned	8¾ oz	62.5 oz
" 11	14	3.787	60 "	Granules	9 oz	64.2 oz
" 13	13½	3 583	60 "	Overchurned..	6 oz	44.4 oz
" 13	13½	3 583	60 "	Granules	6½ oz	48.1 oz
" 16	19½	3 583	60 "	Overchurned	14 oz	71.7 oz
" 16	19½	3.583	60 "	Grannles	15 oz	76.9 oz
" 20	14	3.379	60 "	Overchurned	8½ oz	60.7 oz
" 20	14	3.379	60 "	Granules	7 oz	50 oz
" 30	14	3 583	60 "	Overchurned	8¾ oz	62 5 oz
" 30	14	3 583	60 "	Granules	7½ oz	53.5 oz

In these tests in five cases out of nine, the overchurning of the cream gave an average of 6 36 ounces more of butter per hundred pounds of milk than did churning the cream to the granulated condition. Four cases out of nine tests, the overchurning of the cream gave an average excess of 3.32 ounces per hundred pounds of milk in favor of churning to the granulated condition. The butter made each day received the same amount of salt, and the result is given in good marketable butter; the weights being taken after the operation was completed.

Methods of Testing Milk.

The interest being developed in dairying has directed the attention of scientific investigators to some cheap and efficient means of quickly analyzing milk. A number of processes have recently been proposed, each having its defects, and each in its turn requiring the attention of the Chemist of the Station in testing its efficiency and detecting its weakness. All of the methods proposed contemplate the use of strong chemicals for setting free the butter fat in the milk and then measuring the quantity of fat or fatty acids liberated from the known quantity of milk, and calculating therefrom the per centage composition of the milk. Much time at the Station has been spent in endeavoring to arrive at the limits of error in each, and also in finding the defects or difficulties to be overcome. All of the methods proposed depend for their accuracy upon measuring the fat in an accurately graduated tube. Supposing the chemical work of the operation to be perfect, there will always be a liability o error in the irregular calibration and graduation of the tubes.

To the writer's mind, there appears to be no reason why such a process of milk analysis may not be made as reliable and accurate as an ordinary volumetric determination in chemical analysis. Until within comparatively recent years, the majority of chemists looked with a good deal of doubt upon results secured by volumetric processes; but the improvement in the manufacture of glass apparatus and in the methods of calibration and graduation, and the processes of analyses have so perfected the operations that for many kinds of analyses, the volumetric methods are accepted as being equally as reliable as gravimetric. The chemist in proposing to use any of these methods, must, of course, carefully test all of his apparatus before beginning operations in order to secure the utmost accuracy. The sources of error most frequently met with in our experience have been inaccuracy of gradution in the tubes for measuring the fat. The manufacturers did not appreciate the necessity of having the necks of the tubes of uniform bore, and this difficulty can only be overcome in the chemical laboratory by correcting all of the tubes for these errors, as is done in other careful work by volumetric methods.

Short's Method.

Short's method of analysis consists in digesting 20 c. c. of milk with hot alkali in a narrow necked flask prepared for the purpose until the caseine is decomposed and the butter fat converted into soap. The soap is then decomposed by hot acid, which further decomposes the caseine and liberates the fatty acids so that they may be collected and measured in the narrow tubular neck of the flask. The tubes in the latest form are graduated to give the per cent. of butter fat found in the volume of milk, and after the de composition is effected, nothing remains but to read off the percentage of fat in the butter.

The apparatus necessary for carrying on this operation consist of three pipettes, one holding 20 cubic centimeters for measuring the milk, and the other two each holding 10 c. c. for measuring the alkali and acids used. The scale, we think, should be engraved upon the tube; some manufacturers, however, furnish tubes that are not graduated, and with them, a millimeter scale for measuring the percentage of fat. It requires a water bath provided with the proper rack for holding the tubes while being heated and a wash bottle for holding hot water. The chemicals used are:

Solution No. 1 consisting of 8.75 ounces (250 grams) caustic soda, 10.7 ounces (300 grams) caustic potash, dissolved in 4 pounds (1809 grams) of water.

10 c. c. of this solution are added to the milk to convert the butter fat into soap, and to partially decompose the caseine.

After adding this solution to the milk, the tube is placed in the water bath and boiled continuously for about two hours until the whole mass assumes a dark brown color. During the process of boiling, the tubes should be shaken once or twice to be sure to have all parts of the milk perfectly acted upon.

Solution No. 2, consisting of equal parts of commercial sulphuric acid (oil of vitriol) and acetic acid. The acetic acid should have a specific gravity of 1.047.

After the milk and alkali have been boiled together for about two hours and the decomposition is quite complete, the tubes are removed from the water bath, cooled slightly and 10 c. c. of solution No. 2 added to each of them. The tubes are then returned to the water bath and boiled for an hour. They should be shaken two or three times during this digestion. Remove the tubes from the water bath and fill them up by means of the wash bottle with hot water to within an inch of the top, or if they are graduated tubes, so that all of the fat will stand within the graduated scale. The slight turbidity or coloration of the fat does not appreciably affect the accuracy of the result. These impurities may be very perfectly removed by allowing the fat in the tubes to crystalize and then remelting it. If lumps of caseine should rise with the fat, it indicates that the digestion has not been long enough, and care should be observed that these do not effect the reading of the result.

The same process may be used for the analysis of cream by mixing the cream thoroughly and withdrawing 20 c. c. of the well mixed cream, then by adding to this 60 c. c. of water and shaking vigorously until the cream is thoroughly mixed with the water. Take 20 c. c. of this mixture and introduce into the flask and proceed as if it were whole milk. The reading should be multiplied by four to find the correct per cent of fat in the cream. Our results in the analysis of cream by this method have not been so satisfactory as with whole milk.

The author of the process does not claim for it correct results for skim-milk containing less than one-half per cent of fat, as the relation to the composition of the skim-milk to the fat globules appears

to be changed in some way, so as to prevent the thorough separation of the butter fat.

The sources of error to be guarded against in this process are :

First. Unfair samples of milk.

Second. Inaccurate tubes, both for measuring milk and for measuring fat.

Third. Insufficient digestion with the alkali or acid.

Fourth. Inaccurate reading of the result.

The method, when properly handled, is believed to be sufficiently accurate for commercial purposes, and with proper experience may be relied upon as giving sufficiently accurate results for the determination of the quality of the milk received at the creamery. It is an important advance over the oil test so largely used in some parts of the country.

Patricks' Process, or the "Iowa Station's Milk Test."

The principle of Patricks' test, published in Bulletin No. 8 of the Iowa Station, February, 1890, is to dissolve the caseine and other ingredients of the milk by means of chemicals, and heat, and to allow the melted fat to rise and collect in a narrow tube, where its volume can be read with accuracy.

The complete apparatus consists of a sand bath or shallow pan holding sand provided with a rack which carries the tubes for heating, the tubes for containing the assay ; an acid mixture ; a pipette for measuring milk ; a long stout pin for lowering the milk in the tube and a tube brush forcleaning the tubes. In place of a sand bath, he has recently proposed a brine bath containing a saturated solution of salt.

Patrick uses 10.4 c. c. of milk as the assay volume. He proposes three formulæ for the acid mixture:

Formula No. 1.

Pure acetic acid of 90 per cent. strength, 9 volumes.

Commercial oil of vitriol (sulphuric acid), sp. gr. 1.85, 5 volumes.

Mix, cool thoroughly, then add hydrochloric acid, sp. gr. 1.19, 1 volume.

Finally dissolve as much sulphate of soda (Glauber's salts) in the powdered form in this mixture as is possible by shaking or stirring, allowing a small excess of the crystals to settle to the bottom. Keep in a cool place in a glass stoppered bottle.

Formula No. 2.

Pure acetic acid, 90 per cent. strength, 9 volumes.

Commercial oil of vitriol sp. gr. 1.83, 5 volumes.

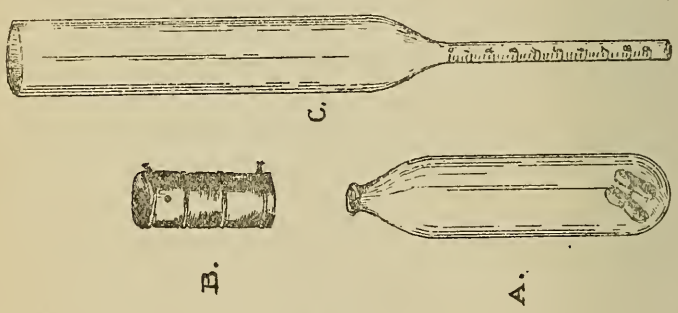
Mix, cool thoroughly, then add chemically pure hydrochloric acid, sp. gr. 1.19, 2 volumes.

Saturate with sulphate of soda (Glauber's salts), as in No. 1.

Bottle and preserve in the same way.

The most approved form of test tube devised by Patrick is shown in the accompanying cut, and has the advantage that the surface of the fat column can always be brought to the zero mark to facilitate the reading. It consists of two glass parts A. and C. and a thick rubber connecting tube B. The latter is wired firmly to A, but allows the grauduated neck C to be moved up and down inside of it with moderate friction. During the boilding, the neck is kept close down to A, but when the time for lowering the fat arrives, it is drawn up until its lower end is but a little below the small hole in the rubber B., and through this hole the liquid is easily withdrawn by the aid of a long, stout pin. Should the surface of the fat in lowering happen to be brought a little below the zero mark, or should it fall below by reduction of temperature, its position can at once be readjusted to that mark by pressing the neck a little lower into the rubber B. Some small pieces of pumice stone are placed in A. to prevent bumping during the digestion of the milk.

Fig. 4a.



Formula No. 3.

Acetic acid (pure) 90 per cent. strength, 9 volumes.

Sulphuric acid (oil of vitriol) spirit grains 1.83, 5 to 6 volumes.

Mix, allow to cool and add to the mixture about 2 per cent. by volume of rectified Methylic alcohol (wood spirit.)

From 13 to 15 c. c. of either of these solutions is added to each assay.

Method of Procedure.

Measure the assay volume 10.4 c. c. of milk into a tube by means of the pipette. Now pour in acid mixture in a small stream in the small test bottle to within an inch or less of the neck, leaving room for mixing the contents. Shake vigorously to thoroughly mix the acid and the milk, add acid mixture again up to three-forths of an inch above the top of the neck. Wipe the outside of the tube dry

and place it in the rack on the sand bath, or in the brine bath. The sand bath should contain sand free from gravel to the depth of about half an inch, a little more if a very hot fire is to be used. When all the samples of milk are prepared in this way and placed upon the sand bath, heat over a brisk fire (an ordinary kitchen stove, oil or gasoline stove may be used) bringing the contents of the tubes to a boil, and boil briskly but not violently for 4 to 6 minutes; by this time, the froth which at first forms will have dissappeared and the curd of the milk will be dissolved.

Acid mixture No. 1, does not develop any turbidity, but requires a little longer boiling than it does with No. 2, which will develop turbidity if the boiling continues too long.

No. 3 is used upon composite samples or preserved milk. In using this solution, throw into the tube on top of charge about a thimble full of anhydrous sylphate of soda.

The tubes may be made to boil regularly by raising or lowering ing them in sand; the ones boiling too rapidly being drawn out, and the ones not boiling with sufficient rapidity being pushed farther into the sand. After boiling a sufficient length of time, the sand bath may be removed from the stove to check the boiling, or it may be done by lifting the tubes for a moment from the sand; this will allow the fat to rise to the surface. As soon as the fat has risen, set the sand bath again over a heat sufficient to boil the contents of the tubes gently so as to move the fat layer up and down to mix it slightly with the surface portion of the acid liquid. This operation clarifiies the fat and relieves it from any inclosed impurities. If the fat is not clear after five minutes of this treatment, sprinkle upon the fat layer while it is being gently agitated as described, a little "efflorsced" sulphate of soda. If perfect clarification does not ensue almost immediately repeat the dose under the same conditions. Under this treatment, the time required for complete clarification with a fresh milk rarely exceeds eight minutes, and usually five suffice. Now remove the entire apparatus from the stove.

Effloresced sulphate of soda may be secured by pulverizing common Glauber's salts and exposing a thin layer of the powder to the air for a few days until the water of crystalization passes off, when it will be a fine, white powder. The finer and dryer it is, the better. It is used for clarifying the fat in the tube and in the preparation of the solutions.

For any purposes, where moderate accuracy is demanded, it suffices to at once lower the fat into the neck of the tubes and measure; but where greater accuracy is desired, after slight cooling, they should be set all at once by the movable rack into a pail of water kept at about 140 degrees F., and left there for 7 to 8 minutes before lowering. This brings the fat to the correct temperature, also makes it still clearer and renders exact measurement easier. After lowering the fat, the tubes should be replaced in the water for a few minutes to allow the fat to drain down completely before

reading; the readings may then be taken after an immersion of 10 to 15 minutes all told.

Lower the fat into the neck of the tube through the hole in the rubber band by using a stout pin which accompanies the tubes, as a lever to raise the rubber from the orifice in the tube lying just under the circular hole in the copper ring and allow the acid liquid to escape.

Both the upper and lower surfaces of the fat should be perfectly clean and distinct when the measuring is done. Should either be obscured by small bubbles and adhering brown liquid, these can be readily removed by inserting in their midst a slender splint of broom corn, twirling it rapidly between thumb and finger, and then returning the tube to the warm water to settle for a few minutes. As the broom splint is withdrawn, allow the adhering trace of fat to drain off upon the glass just above the column of fat.

Measure the fat from the extreme upper to its extreme lower surface; pay no attention to the meniscus—the dark crescent shaped appearance just below the upper surface.

The numbers on the graduations indicate percentages of butter fat, by weight—that is, pounds of butter fat per 100 pounds of milk. Each small division means .2 of one per cent., that is one-fifth of a pound per 100 pounds of milk), and it is easy to read to one-half, and with practice even to one-fourth of a division.

In ungraduated tubes, the fat is measured with a small millimeter scale, in which case, special directions accompany each set of tubes.

Special Precautions.

1. In charging the tubes, empty the pipette completely of milk, draining for a few seconds and blowing through it.

2. Bring the contents of the tubes to a boil as quickly as possible. If acid mixture No. 2. is used, boil briskly only four minutes; much longer boiling is liable to make clarification more difficult.

3. After the first boiling is over and all boiling has ceased, allow sufficient time (two or three minutes usually) for all the fat to rise to surface before commencing clarification. Observation through the neck of the tube toward the light of a window will tell when all has arisen.

4. In clarifying, boil only briskly enough to agitate the fat and mix it with the surface portion of the acid liquid, but not briskly enough to carry any fat down again into lower part of the tube.

5. In lowering the fat, rest the tube on some support; do not try to hold it in mid-air.

6. If the plan of hot reading be adopted, *i. e.* reading as soon as clarification is done, without setting into water—make sure before reading that all the fat has risen to the surface.

7. Where only comparative analyses are being made, the standing of tubes in water at 140 degrees F. can be omitted; but it gives results in this ease from .15 to .25 per cent. higher than where an immersion of half an hour has been followed. It seems to be necessary to allow the fat to stand at about 140 degrees for twenty or

thirty minutes in order that it may assume a fixed volume. Where a number of tests are made at the same time, an extra rack is provided for them, so that they may be immersed in hot water as they are completed by the sand digestion.

Where only comparative analyses are made, and the short cut plan of reading the fat hot is taken, about one-half dozen tests may be made in half an hour.

Sources of Error.

The only danger of error from a chemical source appears to be the failure to completely dissolve the non-fatty parts of the milk. The operator, however, can always tell whether the method is working satisfactorily or not, as a clear, nearly or quitet transparent solution of the milk with a clear fat layer free from curd or scum is a sure proof of the successful working of the test.

The digesiton by Patrick's method is more satisfactory than by Short's method, and less liable to have errors arise from imperfect digestion. It also has the advantage of requiring less time and of having the whole process performed by one operation. The lowering of the liquid, however, is inconvenient, and trouble with the rubber tubes is liable to arise. It is, however, a valuable addition to our methods of milk analysis.

As in Short's method, the graduation of the tubes is the chief source of error to which the method is liable, and the only protection that the chemist has from error arising in this manner is to carefully test all the tubes used by him. The manufacturers of these various tubes are liable to be careless, and unless it is understood that inaccurate tubes are to be returned to them at their expense, one is apt to secure a large proportion of inaccurately graduated tubes. The Iowa Station agrees to test, free of charge, the tubes that are sold by J. F. McLain, of Ames, Iowa.

Cream by this method is tested by diluting with two or three volumes of water, multiplying the result by three or four according to the dilution. The results by this process appear to be a fraction higher than those secured by the gravimetric method for whole milk and skim milk, and a fraction lower for cream.

Some results by Shorts' and Patricks' methods as they appear in the ordinary work of the creamery is shown by the following:

I		II	
Shorts'.	Patricks'.	Shorts'.	Patricks
A. 4.75	4.50	A. 3.50	3.50
B. 4.50	4.44	B. 4.65	4.78
C. 3.40	3.67	C. 4.40	4.44
D. 4.30	4.38	D. 4.40	4.44
E. 5.90	5.07	E. 4.25	4.11
F. 4.25	4.23	F. 4.70	4.49
G. 3.90	3.88	G. 4.35	4.38
H. 4.25	4.22	H. 4.35	4.38
I. 4.50	4.56	I. 3.25	3.11
		J. 4.20	4.22

Cochran's Method.

The other process depending upon the action of chemicals and somewhat similar in principle to that of Patricks', is the Cochran method. He claims to hold a patent upon it. The particular form of apparatus no doubt is patentable; but it would be as reasonable to patent electricity as a chemical reaction. The apparatus essential to conducting this process is a steam boiler with a wire rack in it for holding the tubes while being heated; a pipette for measuring the milk, one for measuring ether, one for measuring acid, and a digesting flask having two narrow necks, the flask holding about 100 cubic centimeters. The larger neck enters the flask about half way up, and the narrow neck, carrying upon it a scale, enters it at the top.

The chemicals used are:

Good commercial sulphuric acid specific gravity 1.82.

Acetic acid, sp. gr. 1.073.

These may be mixed, but if so, care must be taken to keep the bottle closely stoppered to prevent the escape of the volatile acid. Ordinary, ether, which should be kept in a cool place well stoppered, and never poured out when near a naked flame.

A pound of each of these reagents will suffice for about 200 analyses.

The process of analysis is as follows:

5 cubic centimeters of thoroughly mixed milk, or cream diluted as in Short's method, is measured into the wide mouth of the flask.

5 cubic centimeters of the acid mixture or 2 and ½ c. c. of each, if kept separately, are added to the milk, and the sample thoroughly shaken. In the meantime, the water in the water bath is heated to boiling, and the wire rack so placed that the flasks will be immersed about one-half inch in the boiling water. The flasks containing the milk and acids are heated for five or six minutes, shaking thoroughly once or twice to keep the contents well mixed. Then place the flask in cold water. When the flask is cooled, measure out 4 c. c. of ether. Mix thoroughly with the contents of the flask by shaking, and set in the boiling water again until no smell of ether can be perceived at the mouth of the flasks; this usually takes ten to fifteen minutes. The fat is thus brought to the surface in a clear layer. The flask may then be filled up with hot water above the mouth of the side tube, care being taken that no fat enters it. Should any enter, it may be drawn back into the flask by blowing upon it. Some care will be required to see that none of the butter fat clings to the side of the flask. It should all be carefully worked to the surface by shaking or jarring the flask before filling with hot water to the narrow neck. Hot water is then carefully run into the side tube, causing the fat to rise in the graduated tube.

If the column of fat in the tube be broken by bubbles of water or air, continuity can be restored by running a small broom splint

PLATE 7.

COCHRAN'S MILK TESTING APPARATUS.

or polished wire down through it and twirling it. Allow any adherent fat to drain off be ore removing it.

The division upon the scale reads per cents to one-tenth of one per cent. The reading should be done while the column is hot, and should extend from the upper surface of the top bottom of the fat column. The difference in reading will give the per cent.

The table supplied with the instruments gives the per cent. of fat per hundred pounds of milk:

Percentage of Fat Corresponding to Cochran's Measures.

Measure of fat.	Per cent. in milk.	Measure of fat.	Per cent. in milk.	Per cent. in cream.	Measure of fat.	Per cent. in milk.	Per cent. in cream.	Measure of fat.	Per cent. in cream.
0.5	.173	10.0	3.46	7.03	20.0	6.92	14.06	30.0	21.09
1.0	.346	10.5	3.63	7.38	20.5	7.09	14.41	30.5	21.44
1.5	.519	11.0	3.80	7.73	21.0	7.26	14.76	31.0	21.79
2.0	.692	11.5	3.97	8.08	21.5	7.43	15.11	31.5	22.14
2.5	.765	12.0	4.15	8.44	22.0	7.61	15.47	32.0	22.50
3.0	1.038	12.5	4.32	8.79	22.5	7.78	15.82	32.5	22.85
3.5	1.211	13.0	4.50	9.14	23.0	7.95	16.17	33.0	23.20
4.0	1.384	13.5	4.67	9.49	23.5	8.13	16.52	33.5	23.55
4.5	1.557	14.0	4.84	9.84	24.0	8.30	16.87	34.0	23.90
5.0	1.730	14.5	5.01	10.19	24.5	8.47	17.22	34.5	24.25
5.5	1.903	15.0	5.19	10.54	25.0	8.65	17.57	35.0	24.60
6.0	2.076	15.5	5.35	10.89	25.5	8.83	17.92	35.5	24.95
6.5	2.249	16.0	5.53	11.25	26.0	9.00	18.28	36.0	25.31
7.0	2.422	16.5	5.70	11.60	26.5	9.17	18.63	36.5	25.66
7.5	2.595	17.0	5.88	11.95	27.0	9.34	18.98	37.0	26.01
8.0	2.768	17.5	6.05	12.30	27.5	9 51	19.33	37 5	26.36
8.5	2.931	18.0	6.23	12.65	28.0	9.69	19.68	38.0	26.71
9.0	3.114	18.5	6.40	13.00	28.5	9.86	20.05	38.5	27.06
9.5	3.287	19.0	6.57	13.36	29.0	10.03	20.39	39 0	27.42
		19.5	6.74	13.71	29.5	10.20	20.74	39.5	27.77
					30.0	10.38	.....	40.0	28.12

As used at present, it is intended only for commercial analyses; but by making finer divisions upon the scale, it can be made use of for closer determinations, if handled with proper care. The apparatus is sold by Marshall & Cochran, 215 North Fifth street, Philadelphia, Pa.

All the methods described depend entirely upon chemicals for effecting the separation of the fat from the milk. Each of the methods can be relied upon for commercial analyses, and really mark a great advance in the process of analysis of milk. By the careful and proper graduation of the tubes; it is indeed entirely within the range of possibilities that by them analyses of milk may be quickly made, giving results comparable with the gravimetric method.

None of them, however, are quick enough to fully answer the purpose of testing milk for creameries, and during the year, two more advances in the process of milk analysis have been made. One by Dr. Babcock, of the Wisconsin Station; another by the Vermont Station, which has been tested, or at least the chemical investigations have been carried on under the direction of Dr. Cook of that Station. The machine is called Beimling's apparatus, the machine itself being patented by him. The Babcock apparatus is not patented by him, but forms of apparatus for carrying out his process have been patented.

Any method to be satisfactory should possess the following qualities, *i. e.:* Ist. It should be simple, requiring no knowledge of chemistry and little skill in handling apparatus. 2nd. It should be cheap both as to apparatus and chemicals used. 3rd. It should be accurate, and the more accurate it is, the better. The analyses for commercial purposes should be reliably made to about .1 of 1 per cent. 4th. The method should be rapid, so that a large number of analyses may be made in a short time. While the three methods already discussed require from one to three hours to complete a series of twenty samples, with the apparatus of Beimling or Babcock, the work may be more perfectly done in an half hour or less.

The apparatus which I shall next describe is Babcock's Apparatus, a cut of which is herewith represented.

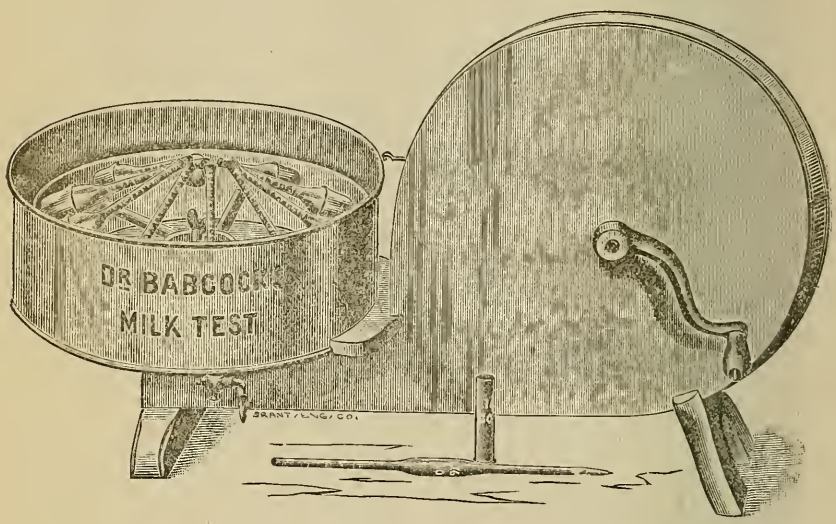


Figure 5.

"1. Test Bottles. These are of the same form as the bottles used in Short's test, but are made a little smaller and of heavier glass. They should contain up to the neck not less than 40 c. c. and not more than 45 c. c. Each division of the graduated scale upon the neck represents .04 c. c., and in order to facilitate the reading, the neck is made of such a diameter that the marks of the scale are about 1½ millimeters apart. Five of these divisions are equivalent to one per cent. of fat when 18 grams of milk are used in the test, it being assumed that the specific gravity of the butter fat, at the temperature at which the reading is made (about 120 degrees Fahr.) is 0.9." Each division, therefore, on the scale corresponds to one-fifth of one per cent.

2. Pipette for measuring milk. This may be of any form, but one with a rather wide opening at the lower end, to allow the milk to run out rapidly is to be preferred. It should contain when filled to the mark, 17.6 c. c. A pipette of this size will deliver a little less than 17.5 c. c. of milk. The quantity of the milk required for the test sample of 18 grams is 17.44 c. c., if the milk has the average specific gravity of 1.032.

3. A measure for the acid. A graduate or cylinder of glass with a lip to pour from and a single mark at 17.5 c. c. is the best for general use. In laboratories, a large burette holding 100 c. c. or 200 c. c. with marks at each 17.5 c. c. and having a glass stop cock, may be used to advantage, but on account of the liability to breakage is not be recommended in factories or private dairies.

4. Centrifugal machine. Any kind of centrifuge may be used that will give a speed of from 700 to 800 revolutions per minute. The cut, furnished by Cornish, Curtis & Greene, of Fort Atkinson, Wisconsin, represents the particular form of machine supplied by them.

The form devised by Dr. Babcock is mounted on a stand not dissimilar to the stand of a separator. The tubes containing the acid are shown in place in the cut. The cylinder is made to revolve by means of a crank with a band running on large and small pulleys, giving a horizontal motion to the tin cylinder carrying the test bottles. This is provided with a cap and with provisions for supplying it with hot water or steam. For this purpsse, a kerosene lamp or Bunsen burner may be used, or connections may be made with the boiler so as to keep a constant supply of steam in the jacket.

The chemical used is commercial sulphuric acid, having a specific gravity of 1.82. Stronger acid should not be used, as it chars the fat.

The pipette for measuring milk and the measuring flask for the acid are shown in the cut.

Making the Test.

Sampling the milk. Every precaution should be taken to have sample represent as nearly as possible the whole lot of milk from which it is taken. The milk should be poured several times from one vessel to another, or agitated in such a way that the sample may be thoroughly mixed. No clots of cream should appear on the surface or small granules of butter. Sour milk is very difficult to sample, and where it is necessary to analyse it, a pint of the well stirred milk should have the curd disolved by mixing with it 5 per cent. of strong ammonia water. When this is done, 5 per cent. must be added to the result obtained in order to get the corrent percentage.

The milk is measured into the tubes by means of a pipette furnished with the apparatus for that purpose. The tubes may all be numbered, and all receive the samples of milk one after another, by rinsing the pipette with the milk before drawing it full of the sample to be used. The sample should always be drawn immediately after

thorough shaking so that the milk measured off will fairly represent the whole milk. The acid is then measured into the test bottle, which may stand a day or two, if necessary, without changing the results.

If curd is formed in the tube, it should be broken up by thoroughly skaking it.

The amount of commercial sulphuric acid required is approximately 17.5 c. c. If less is used, the caseine is liable to be imperfectly dissolved and rise in the column of fat. If more than 17.5 acid is used, the fat is liable to be attacked by it. The acid and milk should be thoroughly mixed by shaking. At first a precipitate of curd from the milk appears, which rapidly dissolves. A large amount of heat is formed by the chemical action of the acid upon the milk, and the solution soon becomes a dark brown. After standing a short time, the fat begins to accumulate on the surface having the appearance of dirty cream.

Dr. Babcock gives the following description of making the test:

Whirling the bottles. The test bottles containing the mixtnre of milk and acid may be placed in the machine directly after the acid is added, or they may stand several hours without harm. An even number of bottles should be whirled at the same time, and they should be placed in the wheel in pairs opposite to each other, so that the equilibrium of the apparatus will not be disturbed. When all of the test bottles are placed in the apparatus, the cover is placed upon the copper jacket, and the machine is turned either by hand or by power at such a rate that the wheel carrying the bottles will make from 600 to 800 revolutions per minute, and this motion must be kept up for six or seven minutes. If this wheel is less than about 20 inches in diameter the speed should be greater, or else the whirling should be continued for a longer time.

When the bottles are placed in the machine directly after the acid is added, the separation may be affected without any extra heat, as that caused by the chemical action is sufficient to keep the fat liquid. If the bottles have stood after the acid is added until the contents are cooled below 100 degrees F., the water in the tank should be warmed to about 200 degrees F. before putting the bottles in the machine. The bottles should be kept heated in the machine as high as the boiling point of water while the separation is being effected. The proper degree of heat may be obtained by lighting the burner or kerosene stove under the jacket when the machine is started; so much water having been poured into the jacket as will be just heated to boiling when the whirling is finished. In this way, hot water is always available for filling the tubes at the proper time. In creameries, heat can be most easily supplied by steam connection with the boiler. If the machine is stopped for about six minutes, a layer of fat will be found upon the upper surface of the liquid in the tubes. This fat will not usually be clear; this, however, will make no difference in the result, as the subsequent treatment will clarify it.

As soon as the bottles have been sufficiently whirled, they should

be filled to the neck with hot water. This is most conveniently done by placing a vessel containing boiling water above the machine, and by means of a syphon, made from a small rubber tube with a glass tip, run the water directjy into the bottles without removing them from the wheel. The flow of water can be perfectly controlled by a pinch-cock upon the rubber tube If only a few tests are to be made, the bottles may be easily filled with a pipette, or by pouring from a graduate. The cover should then be replaced and the machine turned for one or two minutes, after which more hot water is added, filling the tube to about the seven per cent. mark. The fat will slowly rise into the graduated tube losing its cloudy appearance as it passes through the hot water. When all the bottles are filled, the cover is put upon the tank and the machine again turned for a short time. During this time, the water in the tank should be kept hot either by placing a lamp or kerosene stove beneath it, or by pouring in a quantity of boiling hot water before starting the machine. If the fat in some of the tubes still has a cloudy appearance, the cover should be placed upon the tank and heat applied for a few minutes, when the fat should become clear and in condition to be measured. The clearing may be hastened by whirling the tubes while hot. When the bottles are allowed to cool off to a point where the fat will crystallize and then warmed again, the fat will usually be much clearer than before, but as this does not materially change the volume of fat, it is considered unnecessary. Even a slight cloudy appearance does not harm. Measuring the fat: The fat when measured should be warm enough to flow readily, so that the line between the acid liquid and the column of fat will quickly assume a horizontal position when the bottle is removed from the machine. Any temperature between 110 degrees F. and 150 degrees F., will answer, but the higher temperature is to be preferred. The slight difference in the volume of fat due to this difference in temperature is not sufficient to materially affect results. A difference in temperature of 40 degrees F., will make less than one-tenth per cent. difference in milk containing five per cent. of fat. To measure the fat, take a bottle from its socket, and holding it in a perpendicular position with the scale on a level with the eye, observe the divisions which mark the highest and lowest limits of the fat. The difference between these gives the per cent. of fat directly. The reading can easily be taken to half divisions or to one-tenth per cent.

If the column of fat is less than about one division, as will sometimes happen with skim-milk, butter-milk, or when it may assume a globuler form instead of a uniform layer across the tube; when this occurs, the fat can usually be estimated with sufficient accuracy by simple inspection, but if an accurate reading is desired, it may be obtained by taking four samples of the milk in four test bottles, and after treating them in the usual way, until the bottles are ready to be filled with water, adding water to three of them only, filling them as full as possible without running them over. After whirling them for a minute to bring the fat all into the neck, the fat may be

poured off from these three tubes into the fourth. If any fat remains adhering to the sides of these tubes, they should be filled a second time with water and the remaining fat poured into the fourth bottle, which is then filled with water, whirled, and the reading taken; this divided by four will give the per cent. of fat. A better way would undoubtedly be to have a special test bottle, holding three or four times as much as the ordinary bottle, that could be used for skim-milk, butter-milk and whey. Three or four times the usual test sample could then be taken, and by adding the proper quantity of acid, the test could be made without transferring the fat.

Cream. The chief difficulty in testing cream lies in the sampling. Cream that is sour, or that has been exposed to the air until the urface has dried, can not be accurately sampled. The same is true of centrifugal cream that is badly frothed. Sweet cream from Cooley cans, that is not too thick to flow readily from the pipette, may be tested with satisfactory results. The process, however, must be modified slightly from that used with milk, as the amount of fat in cream is so large that it can not be measured in the ordinary test bottle, if the usual quantity is taken for the test, besides a much greater error results from the cream which adheres to the pipette than with milk. Both these difficulties may be overcome, by taking two or three test bottles and dividing the test sample into as nearly equal portions as can be judged by the eye. The pipette is then filled with water, and this is run into the tubes in the same way as the cream. If three bottles are taken the pipette is filed with water a second time and emptied into the bottles as before. This serves to rinse the cream from the pipette, and at the same time to dilute it to a point where it can be tested in the same way as milk. The bottles are then treated in the usual manner, and the reading of the of the tubes added together for the per cent. in the cream.

Owing to the low specific gravity of cream, the test sample, if the same volume, will weigh less than that of milk, and consequently the per cent of fat as shown by the scale will be less than is found by the gravemetric analysis, in proportion as the weight is less than 18 grams. Where a delicate balance is available, this error may be entirely avoided by weighing the cream used in the test, and calculating the per cent. of fat by multiplying the scale reading by $\frac{18}{a}$, a being the weight of the cream.

If 17.6 c. c. of cream is taken, and the portion adhering to the pipette is rinsed into the test bottle, a close approximation of the true result may be obtained without weighing, by correcting the scale reading as follows: For a scale reading of 20 per cent., add .25 per cent.; for a scale reading of .15 per cent., add 0.1 per cent. Readings between these may be corrected in proportion. Below 10 per cent. no correction is necessary.

In Dr. Babcock's hands, (as published in the Seventh Annual Report of the Agricultural Experiment Station of the University of

Wisconsin) the analyses by this method compare very satisfactorily with those by gravimetric analyses; being approximately .1 lower. In our hands, while the analyses are very uniform among themselves, they run appreciably lower than analyses made by the Adams' method. By using a proper co-efficient of correction, it would be possible, however, to make the results correspond very closely with those secured by the Adams' method.

The expense of the analyses is insignificant, being less than a half cent a test, and by proper care in handling the bottles, very little breakage need occur. The holders for the bottles in revolving cylinders should be packed with cork, rubber or some other material to prevent the glass from coming in contact with the metal, which will have a tendency to crack the bottles under the severe pressure of the centrifugal force.

Some difficulty may be experienced until the operator becomes acquainted with the use of the chemicals; time of digestion, etc. in order to get the fat in the neck of the tube free from caseine. We have encountered this difficulty in endeavoring to carry out the instructions given by Dr. Babcock; but have generally succeeded in getting the caseine fully dissolved by allowing the milk and acid to stand together for some time before putting it into the centrifuge. No doubt improvements will be made upon the machine in this particular but with some experience, as it is, little difficulty will be found in arriving at results sufficiently accurate for all commercial purposes. See comparative analyses.

Beimling's Method.

The Beimling apparatus, a cut of which is here presented, manufactured by H. F. Beimling, 214 Pembrok Place, Philadelphia, Pa. The apparatus consists essentially of a centrifugal machine, which is patented and so arranged that during revolution, the tubes will stand out in a horizontal position, giving the full effect of the the centrifugal force upon the milk. The machine for making six tests at a time could be carried in a good sized valise, and fastened to a table or window-sill without inconvenience.

The cut shows the form of test bottle, which is not unlike the bottle used in Short's method. It also shows the two pipettes; the larger one holding 15 c. c., and the smaller one holding 3 c. c., used for measuring acid. The chemicals used consists of two liquids made by mixing equal parts of rectified amyl alcohol (fusel oil), and concentrated hydrochloric acid, specific gravity 1.16. The second is ordinary commercial oil of vitriol, sp. gr. 1.83. The sample of milk is introduced into the bottle by means of a pipette. Use care to secure the last drop of milk. Then a 3 c. c. pipette is filled with the amyl alcohol and hydrochloric mixture which is added to the milk in the bottle and thoroughly mixed with it by shaking vigorously. The test bottle is then filled nearly to the neck with the oil of vitriol and vigorously shaken until the acid is well mixed with the milk and the curd almost if not entirely dissolved. Care

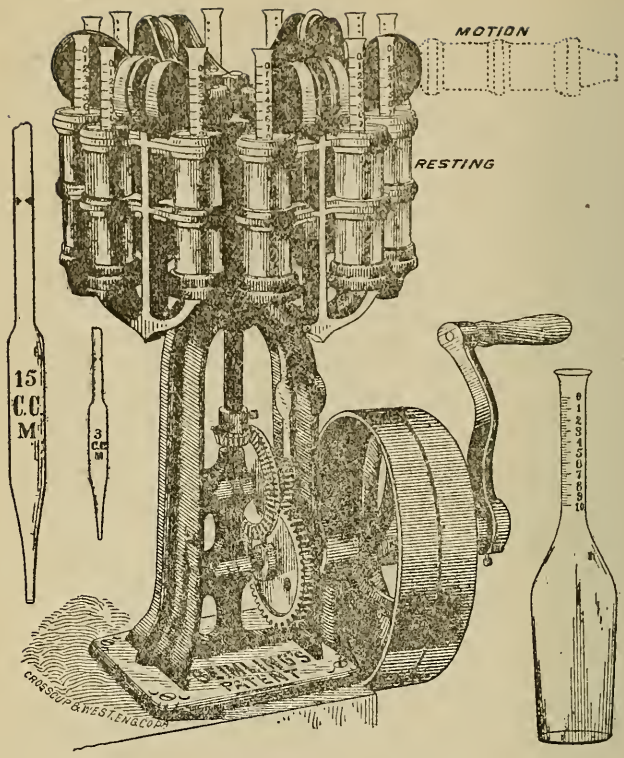


Figure 6.

will have to be observed in this part of the operation, and it will be found convenient to have a small cork for the test bottle to be used while shaking, and withdrawn several times during the operation to allow the air and gas to escape. Considerable heat will be developed by this operation, and it is well to have the bottle wrapped in a towel, or or some other convenient article, to keep it from burning the hands during the shaking: Instead of a cork, an ordinary rubber cap for the finger, such as is on sale at most drug stores may be used. After this has been thoroughly mixed, the bottle is immediately filled to tne zero point with the oil of vitriol, which is mixed with the rest by tipping the bottle upside down a couple of times, and is then placed in the centrifugal machine. A half dozen tubes may be filled in this manner, set in the centrifugal machine and whirled vigorously for half a minute to a minute. On stopping the machine, the clear butter fat will be found in the neck of the bottle, the column of which represents the per cent. of butter fat in the milk.

The danger of cracking the bottles may be largely avoided by placing a disk of cork in the bottom of the metal tube intended to hold the test bottles. This prevents them from coming in contact with the uneven bottom during whirling and will reduce breakage. (Suggested by Dr. Millspaugh after our assistant had broken several bottles. No breakage has occurred since its adoption).

The fat comes up clearly and sharply, and the divisions of the column upon the scale should be read from the extreme limits of the fat column.

The tubes should be kept warm enough to keep the fat column melted, as slight depression of the column gives incorrect results.

In using Hite's table for rapid calculations of the fat content of milk, it must be remembrred that the regular tubes furnished with the Beimling machine are graduated to degrees and tenths of degrees. One degree represents 0.87 per cent of the butter fat. One-tenth degree, therefore, represents .087 per cent.

By using a magnifying glass in extending the scale as practiced at this Station, the table gives the reading for the scale to one-fourth of a tenth of a degree. Thus, for one degree and a little excess, by the magnifying glass estimate what part of the space between one degree and one-tenth degree is the correct reading. If we find it to be 1.025, the per cent of fat is 0.892 per cent. If the correct reading be 1.050, the correct per cent of fat is 0.913 per cent. If the correct reading be 1.075, the per cent of fat is 0.935. If the correct reading be 1.1, the per cent of fat is 0.957.

In using the table, a little time will be necessary to acquire skill to read quickly and accurately with a magnifying glass; but we have been able to accomplish it by a little practice, and after having assured ourselves of the accuracy of the tubes, find it an extremely convenient and quick method of determining the fat in milk.

HITE'S TABLE.

HITE'S EXTENDED TABLE FOR THE RAPID ESTIMATION OF BUTTER FAT BY BEIMLING'S METHOD. THE TUBES GRADUATED TO DEGREES AND TENTHS OF DEGREES. ONE DEGREE REPRESENTS 0.87 PER CENT. OF BUTTER FAT.

Degrees and tenths of degrees, as engraved upon the tube.	Percentage of butter fat for degrees and tenths of degrees, as shown by the divisions of the scale on the tubes.	Percentage of Butter fat for ¼ of the smallest division, or 0.025 added to the percentage for degrees and tenths.	Percentage of butter fat for ½ of the smallest division, or 0.050 added to the percentage for degrees and tenths.	Percentage of butter fat for ¾ of the smallest division, or 0.075 added to the percentage for degrees and tenths.	Degrees and tenths of degrees, as engraved upon the tubes.	Percentage of butter fat for degrees and tenths of degrees, as shown by the divisions of the scale on the tubes.	Percentage of butter fat for ¼ of the smallest division, or 0.025 added to the percentage for degrees and tenths.	Percentage of Butter fat for ½ of the smallest division, or 0.050 added to the percentage for degrees and tenths.	Percentage of butter fat, for ¾ of the smallest division, or 0.075 added to the percentage for degrees and tenths.
Scale	0.000	0.025	0.050	0.075	Scale	0.000	0.025	0.050	0.075
0 0	0.000	0.022	0 043	0 065	5.1	4.437	4.459	4.480	4 502
0.1	0.087	0 109	0.130	0.152	5.2	4.524	4.546	4.567	4.589
0 2	0.174	0.196	0.217	0.239	5.3	4.611	4.633	4.654	4.676
0.3	0.261	0.283	0 304	0.326	5.4	4.698	4.720	4.741	4 763
0.4	0 348	0.370	0 391	0.413	5.5	4.785	4.807	4.828	4 850
0.5	0.435	0 457	0.478	0.500	5.6	4.872	4.894	4 915	4.937
0 6	0.522	0.544	0.565	0.587	5.7	4.959	4.981	5.002	5.024
0.7	0.6 9	0 631	0.652	0 674	5.8	5 046	5.068	5 089	5.111
0.8	0.696	0.718	0.739	0.761	5.9	5.133	5.155	5 176	5.198
0.9	0.783	0 805	0.826	0.848	6.0	5.220	5.242	5.263	5.285
1.0	0.870	0.892	0 913	0.935	6.1	5.307	5.329	5 350	5 372
1.1	0.957	0.979	1.000	1.022	6.2	5.394	5.416	5.437	5.459
1.2	1.044	1.066	1.087	1.109	6.3	5 481	5.503	5.524	5 546
1.3	1 131	1.153	1.174	1 196	6.4	5.568	5.590	5.611	5.633
1.4	1.218	1 240	1 261	1.283	6.5	5 655	5.677	5.698	5.720
1.5	1.305	1.327	1.348	1.370	6.6	5.742	5.764	5.785	5.807
1 6	1 392	1 414	1.435	1.457	6 7	5.829	5.851	5.872	5.894
1.7	1 479	1.501	1 522	1.544	6.8	5.916	5 938	5 959	5 981
1 8	1 566	1.588	1.609	1.631	6 9	6.003	6.025	6.046	6.068
1 9	1 653	1.675	1 696	1 718	7.0	6.090	6.112	6.133	6 155
2 0	1.740	1.762	1 783	1.805	7.1	6.177	6 199	6.220	6 242
2.1	1 827	1.849	1 870	1.892	7 2	6.264	6.286	6.307	6 329
2.2	1 914	1.936	1.957	1.979	7.3	6.351	6 373	6 394	6.416
2.3	2.001	2 023	2,044	2.066	7.4	6.438	6.460	6.481	6.503
2.4	2.088	2 110	2.131	2.153	7.5	6 525	6 547	6.568	6 590
2.5	2 175	2.197	2 218	2.240	7.6	6.612	6.634	6.655	6 677
2.6	2.262	2.284	2.305	2.327	7 7	6.699	6.721	6 742	6 764
2.7	2 349	2.371	2.392	2.414	7.8	6.786	6 808	6.829	6 851
2.8	2.436	2.458	2 479	2.501	7.9	6.873	6.895	6.916	6.938
2.9	2 523	2.545	2.566	2.588	8.0	6.960	6 982	7.003	7.025
3.0	2.610	2.632	2 653	2.675	8.1	7.047	7.069	7.090	7.112
3 1	2 697	2 719	2.740	2.762	8.2	7.134	7 156	7.177	7.199
3.2	2.784	2.806	2 827	2 849	8.3	7.221	7.243	7 264	7.286
3 3	2.871	2 893	2.914	2.936	8.4	7.308	7.330	7.351	7.373
3.4	2.958	2 980	3.001	3 023	8 5	7.395	7.417	7.438	7.460
3.5	3 045	3 067	3.088	3.110	8.6	7.482	7.504	7.525	7.547
3 6	3 132	3 154	3.175	3.197	8.7	7.569	7.591	7 612	7.634
3.7	3,219	3 241	3 262	3.284	8.8	7.656	7.678	7.699	7.721
3 8	3 306	3 328	3.349	3.371	8.9	7.743	7.765	7.786	7.808
3.9	3 393	3 415	3.436	3 458	9.0	7.830	7.852	7.873	7.895
4.0	3 480	3.502	3.523	3 545	9.1	7.917	7.939	7 960	7.982
4.1	3 567	3.589	3.610	3.632	9.2	8.004	8 026	8 047	8.069
4.2	3.654	3 676	3.697	3.719	9.3	8.091	8.113	8.134	8.156
4.3	3 741	3 763	3.784	3 806	9.4	8.178	8.200	8 221	8.243
4.4	3 828	3.850	3 871	3.893	9.5	8.265	8.287	8.308	8 330
4 5	3.915	3.937	3.958	3.980	9.6	8.352	8 374	8 395	8 417
4.6	4.002	4 024	4.045	4.067	9.7	8.439	8.461	8 482	8.504
4.7	4 089	4.111	4.132	4.154	9.8	8.526	8.548	8.569	8.591
4 8	4.176	4.198	4 219	4.241	9.9	8.613	8.635	8.656	8 678
4.9	4.263	4.285	4.306	4.328	10.0	8.700	8.722	8.743	8 765
5 0	4.350	4.372	4.393	4.415					

As regards the accuracy of the work done by this machine, we would say, that it compares very favorably with the results by Adam's method, as is shown by the table of comparative analyses. Where proper care is used in selecting the tubes and having them of uniform bore and carefully calibrated and graduated, results have been secured by us which we consider equally as reliable as those secured by the gravimetric method. By making the neck of the tube narrower and thereby enlarging the scale, or by using a magnifying glass with the ordinary tubes, readings can be made by a little practice to the one-fourth of a division, and by use of the table prepared by B. H. Hite, of this Station, readings corresponding closely with those secured by the most exact processes of analyses have been obtained. The most serious difficulty to contend with in the use of this machine is the calibration and graduation of the tubes. It gives somewhat higher results in our hands than does the Babcock process and is more rapid. The expense is less than half a cent per test. The labor of turning the machine is much lighter than with the Babcock, and taking it all in all, we hold this method of analysis of milk in very high esteem.

Comparative Tests of Butter Milk and Cream by Different Methods.

BY B. H. HITE.

SAMPLE BUTTER-MILK.	Adams.....	Average ...	Beimling.	Average...	Babcock ..	Average ...	Soxhlet ...	Average ...	Cochran ...	Average ...
	0.712		0.261		0.20					
					0.20					
No 1	0.628	0 67	0 261	0.261	0 20					
			0.261		0.25	0,205				
					0.175					
			0.391							
	0.708		0.348	0.377	0 3					
No 2	0 738	0.723	0 391		0.25	0,27				
					0.2					
			0.826		0.2					
			0.783		0.2					
	0 982		0.826	0.815	0 2					
No 3	0.995	0.988	0.826		0.2	0,2				
			0.261							
			0.239							
	0 674		0.239							
	0.658	0.666	0.261	0.250	0 10					
No 4			0 261		0 05	0.075			0.2	
			0 239		5 5				0.2	0 2
			5 590		5 5				0.2	
No 1 Cream. Diluted 1-4	5.534	5 534	5 596	5 556	5.5	5.5				
			5 481		5 3					
					5 3					
No 2, Cream Diluted 1-4	5.42		5 594		5.3	5.3				
		5 36	5.307	5.35	5 3					
	5 30				5 3					
					4 3					
	4.746		4 393		4.3					
		4 687	4.350	4.335	4 3					
No 3, Cream Diluted 1-9	4.628		4 263		4.3					
					4 3	4.3				
			3.610		3 25					
	3 836		3 632		3.20					
No 4, Cream Diluted 1-6		3 794	3.654	3 632	3.20					
	3.752		3 632		3.25					
					3.20	3 22				
			4.306		4.0				3 6	3.6
No 5, Cream Diluted 1-6	4 508		4 233		4 0					
	4.498	4.503	4 306	4 284	4.0		4.18			
			4 263		4.0		4.17		4.3	
			4 132		4.0	4 0		4.175	4 25	4.27
			4.132							
No 6 Cream Diluted 1-6	4.086	4.086	4.132		3 85					
			4.089	4 123	3 80					
			4.132		3.80	3 82				

Comparative Tests of Milk by Different Methods.—(Continued.)

BY B. H. HITE.

SAMPLE WHOLE MILK.	Adams	Average ...	Beimling..	Average ...	Babcock ...	Average ...	Soxhlet....	Average ...	Cochran...	Average ...
No 1	4.69 4.71	4.70	4.698 4.698 4.741	4.712						
No 2	5.49 5 49	5.49	5.35	5.35						
No 3	5.11 5.09	5.10	4.915	4.915						
No 4	4 69	4.69	4.35	4.35						
No 5	5.05	5.05	5.22	5 22						
No 6	5.058 5.072 5,078	5.069	5.048 5.002 5.002	4.999						
No 7			5.002 4.981 4.959							
No 8	4 904	4,916	4.872 4 915 4.915	4.908						
No 9	4 928		4.915 4.959 4 872							
No 10	5 082 5 066 5.135	5.094	4.959 4.981 4.959	4.966	4.7 4.7 4.7 4.7	4.7	4.98	4 98	4 3 4.3	4.3
No 11	5 182 5.168	5.175	5.002 5.046 5 046	5.031	4.7 4.849 4.949	4.84	4.97 4.96	4.96	4.5 4.5	4.5
No 12	5.086 5.182	5.134	5 002 5.087 5.068 5.046	5.051	5 0 4.95 5.0 5.0	5 0	5.00	5.00	5.15	5.15
SAMPLE SKIM-MILK.										
No 1	0.546 0 558	0 552	0.522 0.565	0.543	0 2 0.2 0.1 0.2 0 1	0.16				
No 2	02.74	0.274	0.348 0.370 0 348	0.355	0.10 0.07 0.10 0.10	0.10				
No 3	0.768 0 754	0.761	0.522 0.522 0.522	0.522	0.3 0.3 0.3 0.3 0.3 0.3	0.3				
No 4	0.776 0.788	0.782	0.500 0.478 0.478	0.485	0.3 0.3 0.3	0.3				
No 5	0.688 0.692	0.690	0.587 0.587 0.565 0.565 0.565	0.574	0.1 0.1 0.2	0.13			0.5 0.5 0.5	0.5
No 6	0.700 0.722	0.711	0.522 0.522 0 530 0,522 0.530	0.526	0.05 0.05 0.05	0.05	1.19	1.19	0 4 0.4	0.4
No 7	0 700 0.728	0.714	0 53 0.631 0.652 0.652	0.645	0.1 0.2	0.15	0.83	0.83		